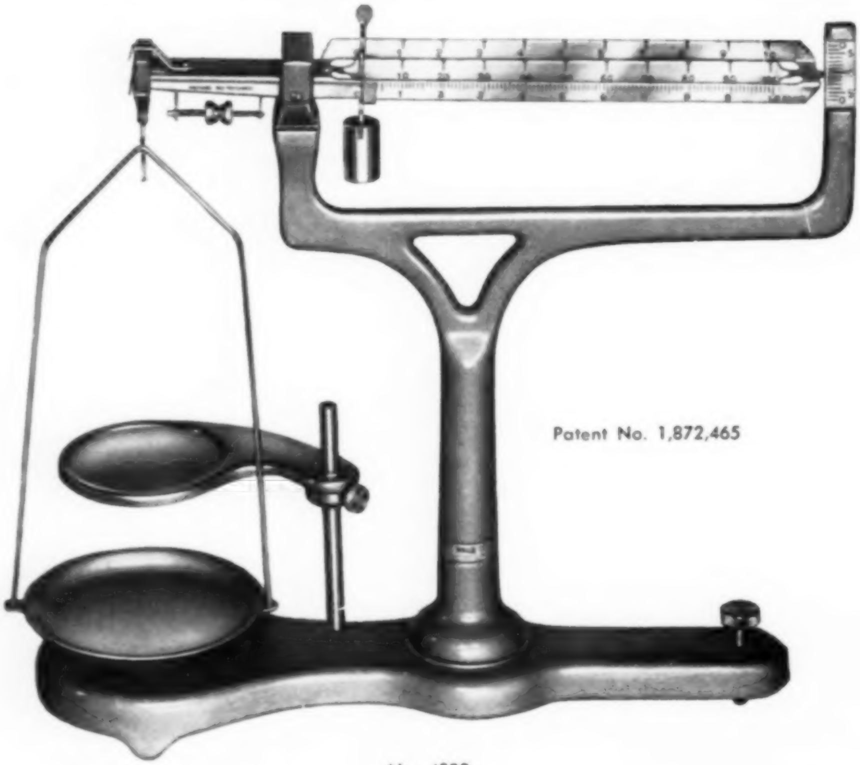
A QUARTERLY JOURNAL OF METHODS AND INFORMATION FOR TEACHERS OF SCIENCE

The SCIENCE COUNSELOR

Volume XIV ★ Number 4 ★ Dec., 1951

DUQUESNE
UNIVERSITY
PRESS



The Science Counselor

"FOR BETTER SCIENCE TEACHING"

A QUARTERLY JOURNAL *of teaching methods and scientific information especially for teachers of science in Catholic schools. Indexed in the Catholic Periodical Index. Published at Duquesne University, Pittsburgh, Pennsylvania, in March, June, September and December by*

THE DUQUESNE UNIVERSITY PRESS

Subscription Price: $2.00 per year; Canada, $2.25. Single copies of issues in the current year, 60¢ each. Business and Editorial Offices at Duquesne University, 901 Vickroy Street, Pittsburgh 19, Pa.

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Planning the Science Room from Within
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Sleeping With Science

• By H. L. Goebel, Ph.D.
CHIEF CHEMIST, KOYLON FOAM DIVISION, *and*
V. H. Hoehn
CHIEF ENGINEER, PRODUCT ENGINEERING, UNITED STATES RUBBER COMPANY, MISHAWAKA, INDIANA

Within the past six or seven years, kneeling, sitting and reclining have all been made more comfortable by the use of soft and resilient foam rubber pads, cushions and mattresses. Even sleeping has become streamlined.

Formed of molded, specially treated, natural rubber into which air is beaten, these new foam latex products of chemical and engineering skill add tremendously to the physical comfort and ease of modern life.

This article tells how they are made.

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Most people spend about one-third of their lives sleeping. Indian fakirs prefer to take their beauty naps on beds of nails. Leaves on the ground or an animal skin on the floor suited our primitive ancestors. The Mexican peasant simply wraps up in his serape. But none of these beds sounds very comfortable to a Twentieth Century American, used to the softness and comfort of a modern mattress.

Many materials may be used in today's bedding, but first on the list for sleeping pleasure is one of the new latex foam mattresses, almost 95 per cent air by volume, soft, porous and resilient. Latex foam is unique among porous rubbers for its almost complete permeability. The interconnecting of the thousands of tiny rubber cells which make it up allows the free passage of air throughout. In short, it "breathes."

Our title, *Sleeping With Science*, implies not that Science is ever caught napping, but rather that it devotes itself not only to splitting the atom, but also to increasing the comfort of modern life. Science and technology have worked together to ensure a good night's sleep to thousands. In this age of streamlined automobiles, luxurious airliners, and electric kitchens, sleeping, older than cooking or traveling, has been streamlined too. The foam latex mattress, made by a rapidly growing industry directly from natural latex, deserves the praise already won in its short life from anyone who wants a comfortable cushioning material. Mentioning softness, uniform support, and comfort, a few of its many virtues, we need not wonder that those who want the very best in bedding choose a foam latex mattress for their homes.

It is possible to make foam from a number of synthetic latices as well as from natural rubber, but to discuss all these possibilities completely would require more space than we may use for this article. We must consider it enough to describe the manufacture of a foam mattress from natural latex, remembering all the while that the same general principles hold for the manufacture of foam from any of the synthetics.

Source and Preliminary Treatment of Latex

To sleep on a foam latex mattress is the easiest thing in the world. But this soft bed is, however, the product of the work of science in a growing post-war industry.

Natural latex is the "sap" of the rubber tree, known to scientists by its botanical name *Hevea Brasiliensis*, which is cultivated for the most part on large plantations in the East Indies, in the steaming jungles of Sumatra and the Malayan Archipelago. These plantations, carved out of the wilderness, are similar in organization to those of the *ante-bellum* South in the United States. Each has its village of native wogs or coolies who diagonally cut the bark of *Hevea*, to allow her precious sap to ooze through the gashes into the crocks waiting to receive it. From these crocks it is collected and processed.

In its natural state, latex is strangely similar to ordinary milk, both in appearance and behavior; hence, it is often called the "milk of the rubber tree." As a colloidal product of natural origin, latex must be carefully handled, protected against the onslaughts of bacteria, and stabilized against the possible premature flocculation that can result from excessive handling and exposure. Ammonia is added to preserve the latex on its long journey to American factories. As it comes from the tree the latex contains a large percentage of water, and in order to be of practical use in the foam industry, it must be concentrated to a total solids content of approximately 60 per cent by means of centrifuging or creaming. All these processes, preservation, stabilization, and concentration are carried out before the latex leaves the plantation.

Following these preliminary treatments, the preserved concentrate travels across the Pacific Ocean to American ports in tankers, and across country from port to manufacturer in railway tank cars. The manufacturer, upon receiving a shipment of latex, transfers it from the cars to large storage tanks where it awaits use.

Foam Mattress Manufacturing

The basic process in foam manufacturing is compounding, in which specified quantities of chemicals, each with its particular purpose, are mixed into the latex now contained in large churns. Sulfur and accelerators are for vulcanization, antioxidants for re-

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What About Dry Ice?

• **By D. H. Killeffer**
CHEMICAL CONSULTANT, CRESTWOOD, TUCKAHOE, NEW YORK

Here are facts about solid carbon dioxide that may not previously have come to your attention.

This article describes how it is made, the qualities that have made it an important industrial product, and its most common commercial applications.

The writer is a well known worker in chemistry. He was technical director of the Dry Ice Corporation of America and holds 14 patents in that field. For nearly a score of years he was on the staff of "Industrial & Engineering Chemistry," American Chemical Society journal, and contributed much through the Society and its News Service. He is author of numerous chemical articles and books, including: "The Genius of Industrial Research," "The First 150 Years," and the forthcoming "Chemistry of Molybdenum" (with Arthur Linz.)

●

This year dry ice, solid carbon dioxide, is twenty-five years old as a commercial commodity in the United States. It now occupies a stable position in our economy both as a refrigerant and as a convenient form for transporting carbon dioxide from points of production to points of large scale use or distribution. From nothing (or at most laboratory demonstration lots) before 1926, production has climbed to a point where in 1950, fifty plants located in 26 states turned out something over 400,000 tons of this intensely cold solid.

A peculiar fascination attaches to this strange material that sublimes directly to a gas at a temperature well down in the range of the coldest polar winters, that forms no liquid as normal stuffs do by melting, and can only melt under a pressure above 75 pounds per square inch absolute, that yields on subliming a gas having high heat insulating value (50 per cent higher than air), and yet that is the same substance familiar as the fizz in soda water and the gas in foaming beer!

In its first commercial applications solid carbon dioxide extended the market for producers of ice cream by making it economical to ship their product over a radius of two to three hundred miles. This was a substantial expansion from the previous 50-mile radius, and developed from the weight saved. Ice and salt in a cedar tub formerly used in transporting ice cream required a gross weight of 150 pounds or more for the package that would contain 5 gallons of ice cream, whereas a dry ice refrigerated paper carton containing the same 5 gallons of ice cream weighed only 38 to 40 pounds. The iced package was good for only a few hours, but the dry-iced carton could be safely shipped for twenty-four hours. A similar contrast developed in refrigerated trucking of ice cream where 60 pounds of dry ice in an efficient truck could carry 500 gallons of ice cream quite as far and more safely and economically than it could be carried by a heavier truck refrigerated with 1000 pounds of ice and 200 pounds of salt.

From these beginnings the industry has branched out into many fields, and presently only about 25 per cent of the output goes to these uses with ice cream. Another twenty-five per cent refrigerates various foods in transit, particularly meat, in trucks, railroad cars, and demountable containers for railroad use having a capacity less than a carload. A third quarter of the solid carbon dioxide produced in this country provides a convenient and economical method for transporting carbon dioxide to be melted and gasified by the user in a pressure vessel so that the gas is available to carbonate beverages. This application has grown large because efficient insulated containers for the solid weigh much less than the steel cylinders required for transporting the same quantity of liquid carbon dioxide, and the loss from the insulated containers has been reduced by efficient insulation to less than three per cent per day, and even as low as one-tenth of that rate. The remaining quarter of the output goes into a variety of uses classed as industrial: production of liquid for carbon dioxide fire extinguishers, cooling metal parts to make tight shrink fits, maintaining annealed aluminum rivets in a soft condition until they are used in airplane and other construction, and a number of other lesser uses.

But solid carbon dioxide was not always of such importance; it had to wait 91 years to find work. From its preparation for the first time in a French laboratory in 1835*, until American ingenuity gave it a commercially useful job to do in 1926, this intensely cold material appeared only in laboratory demonstrations and occasionally was used by physicians to remove warts by freezing.

Because of its picturesque properties and its phenomenal growth, the solid carbon dioxide industry has attracted numerous inventors and investigators who have sought to improve dry ice manufacture, and widen its usefulness. These inventors and investigators have taken out hundreds of patents on their processes; this despite the fact that solid carbon dioxide itself is not subject to patent.

The properties of solid carbon dioxide are unusual and suggest many possible applications. A most important property is that it sublimes directly from the solid to the gaseous state at pressures below 5.11 at-

* Thilorier, *Ann. de Chimie et Phys.*, **60**, 432 (1835).

mospheres, instead of passing from solid to liquid and then to a gaseous state, as most substances do. At one atmosphere (1 atmosphere = 760 mm. mercury pressure), the temperature of sublimation is −78.5°C. (−109.3°F.), 141°F. colder than water ice. This temperature is far below any required in industry, except in the most unusual cases. Liquid air is, of course, much colder, but also much more expensive.

The gas evolved during sublimation has many valuable properties, since it is extremely pure, anhydrous carbon dioxide. Although it is commonly considered to be an inert gas, it is only so with respect to oxidation and reduction at ordinary temperatures. At high temperatures it becomes an oxidizing agent, and will react with metals. In the presence of moisture it produces a distinct acid reaction. Living things, both animal and vegetable, are profoundly affected by carbon dioxide. Since the molecular weight of carbon dioxide is greater than that of oxygen or nitrogen, air and moisture diffuse into it, sometimes with actually measurable pressure. Rubber is highly permeable to carbon dioxide; so much so that a toy balloon, partially inflated with air, will actually blow itself up to the bursting point when it is immersed in an atmosphere of pure carbon dioxide*.

Another especially important characteristic of the gas is its relatively high insulating power against heat. For practical purposes, a layer of dry carbon dioxide (confined to prevent convection, transmission of heat by currents) has about 50 per cent more insulating value than a similar layer of dry air. Part of this greater insulating capacity is imparted to cork, kapok or other insulating materials in which carbon dioxide replaces air. These characteristics of the evolved gas play vital roles in the uses of solid carbon dioxide.

Solid carbon dioxide has no true melting point in the ordinary sense, except under substantial pressure, but sublimes directly to the gas, a fact of the utmost significance. Its effect is two-fold. The latent heat of sublimation, equivalent to the latent heats of fusion and of vaporization, is relatively high, thus permitting the storage of a large amount of "cooling" in small weight and bulk. And, since no liquid phase is involved in sublimation, it has been practicable to build useful refrigerated containers, or trucks, or freight cars, from light-weight materials which would be impossible to use if carbon dioxide melted to a liquid. No drains are necessary, and there is no liquid to corrode the containing vessel.

Process of Manufacture

Manufacture of solid carbon dioxide as normally practiced consists of three essential steps:

1. The concentration and purification of the gas.
2. The liquefaction of the gas.
3. Solidification.

* This property of rubber and carbon dioxide gas can be demonstrated readily by blowing up two identical toy balloons, one with air and one with carbon dioxide. Place the one filled with carbon dioxide in air, and it will deflate itself in the course of an hour. Place the one containing air (which should not be fully inflated) in pure carbon dioxide gas. Within a couple of hours it will have inflated itself to the bursting point.

The details of these steps are, of course, modified by circumstances. The concentration and purification of the gas, particularly, depend on the type of raw material available. Some sources of carbon dioxide yield substantially pure gas (95 per cent or more), containing no nitrogen, oxygen, or other "permanent" gases. In other sources, impurities of this character predominate. In the first category are the gases produced in alcoholic fermentation and as by-products in several chemical operations, and the gas from certain natural wells. In the second group are the gases from combustion, from lime and cement kilns, and from other natural wells and springs of high "permanent" gas content. Gases having relatively high concentrations of carbon dioxide are treated to *remove the impurities* from the carbon dioxide. When there are more "permanent" gases than carbon dioxide present in the mixture, however, the carbon dioxide is removed *from* the impurities.

Gases in the first category are principally scrubbed to wash out unwanted impurities, but those in the second category (flue gases, particularly) are scrubbed with a solution that will readily absorb carbon dioxide in the cold and give it up again when boiled. Such solutions contain sodium carbonate, potassium carbonate or one or more of the ethanolamines (organic water-soluble bases). These solutions function by forming a bicarbonate when carbon dioxide is absorbed and returning to the corresponding carbonate when heated, thus:

$$Na_2CO_3 + CO_2 + H_2O \rightleftarrows 2\ NaHCO_3.$$

The equilibrium in this reaction moves to the right in the cold, but to the left at higher temperatures.

Commercial sources of carbon dioxide used for solidification are:

Gas Wells	5%
Fermentation	35%
Chemical Industry	45%
Flue Gas	15%
	100%

Once the gas is separated in pure form, its liquefaction is accomplished by compression and cooling, the pressure ultimately being raised to about 70 atmospheres. This liquid carbon dioxide may be the commercial product marketed in cylinders, or it may be the raw material for solidification. If it is to be solidified, the next step is to cool it still further, and finally, by its own evaporation, to solidify part of it.

The conversion of the liquid at 20°C. to the solid at −78.5°C. may be accomplished by three different methods. The entire cooling may be done by an external refrigerating system, in which case an ammonia refrigerating machine may be used to cool the warm liquid carbon dioxide to such a low temperature that the liquid freezes. Since this is usually not economical or practical, a second method is often used in which an ammonia system cools the liquid only part way to the freezing point. Then part of the cool liquid is evaporated very rapidly, which cools the rest of the

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Tracerlab—Commercial Radioactivity Center

• By Philip Brady
ADVERTISING MANAGER, TRACERLAB INCORPORATED, BOSTON, MASSACHUSETTS

This is the story of a flourishing commercial organization of a new type that was established only five years ago to fill a single definite need.

From a modest start it has grown rapidly until it now operates internationally and covers the whole field of radioactivity from the design and construction of instruments for detecting and measuring radioactivity to the synthesis of tagged organic and inorganic compounds, and the furnishing of a consulting service.

Industrial and academic studies in nuclear physics and tracer chemistry have been greatly aided by Tracerlab and those associated with it.

•

Tracerlab began, as so many new firms have begun, by filling a need that existing firms were unable or unwilling to meet.

This need? A new instrument required by a group of scientists at Massachusetts Institute of Technology who were doing research in the field of radioactivity. Concerns manufacturing electronic instruments were uninterested in making this new instrument because they could see no future possibilities for them in the nucleonic field. Because of this, the scientists decided to establish their own firm to make the instruments they needed, and which they knew would be increasingly needed as research expanded in the relatively new field of radioactivity.

Tracerlab, Inc., was incorporated on February 28, 1946, as the result of this decision. Ever since then it has been a leader in the rapidly expanding field of commercial radioactivity. From the construction of scientific and industrial instruments for detecting and measuring radioactivity to the synthesizing of tagged compounds and the furnishing of consulting services, Tracerlab covers the whole field of radioactivity.

The radiochemical and electronic activities of Tracerlab are centered in Boston, with a branch laboratory in Berkeley, California. Sales offices are located in New York, Chicago, Washington, D. C., Berkeley and Paris, France. Tracerlab employs over 500 persons including a large scientific staff. The company now owns a one-third interest in a European affilate, Societe d'Application de la Physique Moderne (SAPHYMO). There are authorized distributors in 19 foreign countries.

The importance and growth of nuclear physics and tracer chemistry since the war has exceeded even the ambitious hopes of Tracerlab's founders. The Autoscaler, with which Tracerlab made its debut in 1946, is now only one of several hundred instruments and items of mechanical equipment manufactured by the Company. In addition, a large number of chemical compounds using radioactive "tracer" atoms have been developed for research and industry. These "tracer" compounds betray their presence wherever they go by giving off characteristic radiations. They are employed to extend man's knowledge in medicine, biology, chemistry, physics, and engineering, and to reduce costs and improve the quality of manufactured products. Tracerlab plays a vital role as a link between the huge U. S. Atomic Energy Commission plants and the hospitals, universities and industrial plants, which use radioactive chemicals.

Shipments of radioactive isotopes are received by Tracerlab directly from Oak Ridge to be purified and synthesized into more manageable quantities. The synthesis by Tracerlab of several hundred inorganic compounds with radioactive isotopes, and of fifty organic compounds with Carbon-14, has given a new and invaluable tool to a vast number and variety of research workers.

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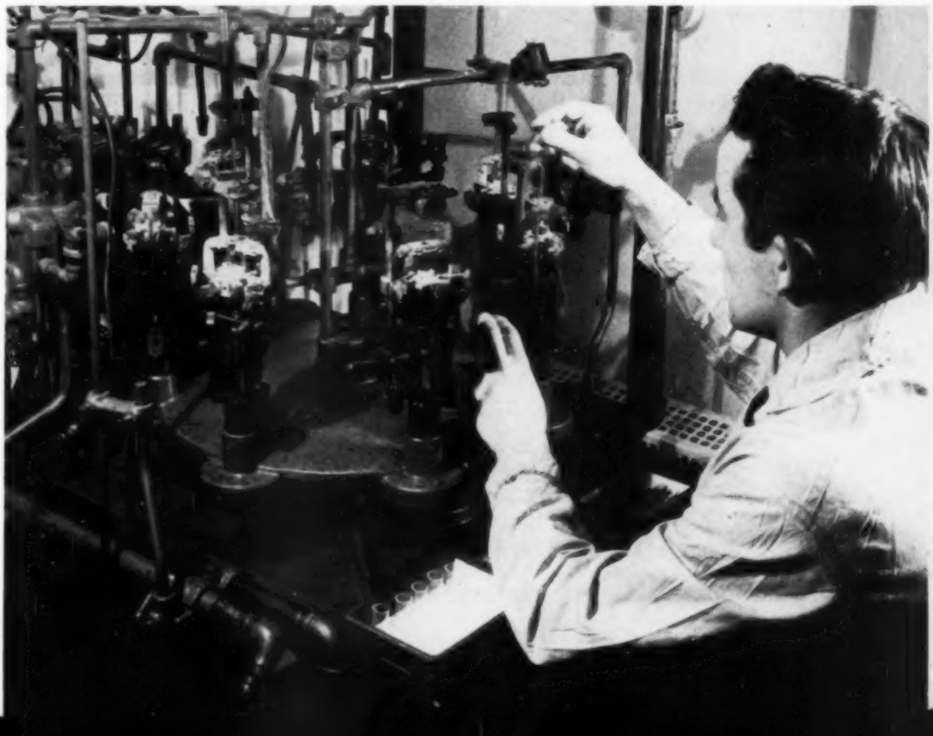
ONE OF THE operations in Geiger Tube manufacture at Tracerlab. Many styles are made.



Chemical Investigation of Ancient Materials and Objects

• By Earle R. Caley, Ph.D., *(The Ohio State University)*
VICE CHAIRMAN, DEPARTMENT OF CHEMISTRY, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

A knowledge of the chemical composition of ancient objects is useful to the chemist, the archaeologist and the historian.

By studying the composition of such objects we have learned that the ancient peoples prepared metals of a high degree of purity, made important alloys, and plated one metal with another. They made glass, and used natural and artificial pigments. Recently we have discovered how to date once living ancient materials by measuring the radioactivity of the carbon they contain.

Dr. Caley tells an interesting story.

The problem of the composition of natural and artificial materials and objects of all sorts has long attracted the attention of the chemist, and a great many different kinds and classes of materials and objects have been repeatedly and thoroughly investigated. Relatively little attention, however, has been paid to the chemical composition of the material remains of ancient civilizations. Such remains constitute a distinct class of materials and objects that are well worthy of investigation, for their composition is not only of interest from the standpoint of chemistry, but perhaps even more so from the standpoint of archaeology and history.

The remains of primitive cultures are generally small in variety and of no great chemical interest, but those of the great ancient civilizations, especially those of Greece and Rome, are great in variety and great in interest. Especially interesting are the metals and alloys of these two civilizations.

Chemical analyses of specimens of metals found in excavations at Greek or Roman sites show that the metallurgists of that day were able to prepare metals having a degree of purity about equal to that of metals produced by the best modern industrial processes. Roman gold or silver coins of the Republic or Early Empire, for example, have been found to contain only a few tenths or hundredths per cent of base metals, and lead from a water pipe of the time of Tiberius, dug up in Rome, was found to have a purity of 99.95%, which is the same as that of the best modern commercial lead.

The art of alloying metals was discovered long before the days of Greece and Rome, but the Greeks, and especially the Romans, made some important alloys for the first time. For example, chemical analyses of many specimens of ancient copper alloys indicate that the important copper-zinc alloy, brass, was probably a Roman invention dating from about the middle of the first century B.C. At the very least, it appears that the Romans were the first to make and use brass deliberately on a large scale. At first, the Romans used brass only as a coinage metal, but later they used it as a material for a great variety of small ornamental objects. Alloys of tin and lead in the form of pewter and solders were also introduced and used extensively by the Romans.

The art of plating one metal with another was practiced to a considerable extent by the Greeks and Romans. Many Greek and Roman coins consisting of silver plated on a copper base have been found. Though some of these are evidently ancient counterfeits, many others are known with certainty to be official state issues. A few examples of large plated objects have been found. For example, there was recently found in Greece a piece of sheet metal, which had apparently once been the side of an ornamental cylindrical vessel, and this was discovered on examination to consist of a copper sheet plated on both sides with a brilliant white alloy of copper, tin, and lead that resembled silver. The arts of soldering and welding were also well known, as has been shown by the metallographic examination of objects composed of pieces of metal joined together.

Of the nonmetallic materials used in antiquity, glazes and glasses are among the most interesting from the chemical viewpoint. Ancient soda-lime glasses are similar in composition to our present bottle or window glass, though they usually contain a little more sodium than modern glass, and as a consequence are less resistant to alteration by air and water. Lead glazes and glasses of high refractive index and brilliancy were discovered and were used to a moderate extent in ancient times. Among the earliest known lead glazes are those that have been identified on Roman pottery found in the excavation of ancient Tarsus in Asia Minor. This pottery dates from about the beginning of the Christian Era. Colored glazes and glasses were produced in great variety in antiquity. Most of these were colored with compounds of common metals, but some were colored with compounds of less common or rare metals. Glasses colored green or yellow with iron compounds or blue with copper compounds are very common, but those colored pink or purple with manganese compounds or blue with cobalt compounds are by no means scarce. One most unusual and unexpected find was a specimen of greenish-yellow Roman glass of the first century A.D., discovered in the ruins of an Imperial villa on Cape Posilipo on the shore of the Bay of Naples, in which the coloring agent was a uranium compound.

Interesting also are the various pigments used in antiquity. Most of these are merely well ground natural minerals, such as red ochre. However, some are clearly of artificial origin, such as white lead, which was made by the chemical corrosion of lead in much the same way as much of our white lead is made at the present time. Another artificial pigment is the so-called Egyptian blue, named from the country where it was first made and used. This has been found by chemical analysis to be a particular silicate of calcium and copper, and from the detailed information obtained by analysis the method of making it has been rediscovered. Still another ancient artificial pigment, apparently first made by the Greeks, is a pink pigment consisting of madder dye on a base of inorganic material. This pigment is interesting as being the forerunner of the modern pigments consisting of organic dyes on a base of aluminum hydroxide, the so-called lake pigments, which are now so widely used.

Relatively few specimens of ancient organic materials have been investigated by the chemist, largely because of the inherently low chemical stability of such materials and their consequent failure to survive. However, chemical analyses have been made of some specimens of ancient dyes, fats, cosmetics, resins and textiles, and some very interesting results have been obtained. For example, the use of mordants for dyes was not only discovered in ancient times but reached a high degree of perfection.

Information derived from the chemical investigation of ancient materials may be very useful to the archaeologist. For example, the accurate identification of materials from excavations enables him to give exact descriptions of these in his publications. Sometimes the chemical identification of ancient materials may lead to inferences and interpretations that are fully as important, or even more important, than the mere establishment of identity for the purpose of exact description. Thus the simple fact that a certain white cosmetic powder, which is known from archaeological discoveries to have been widely used by the women of ancient Greece, is the artificial pigment, white lead, implies its manufacture on a fairly large scale, its sale as an article of commerce, and the use of this poisonous substance in a way that may well have had an adverse effect on the public health.

The presence or absence of certain kinds of materials may be an index of the cultural state of a people. Obviously the absence of metal among the remains of a given people indicates a low state of technical development and a low state of general culture. The greater the variety of metals and alloys utilized by a people, the greater their technical development and, as a rule, the higher their general cultural development. The same appears to be true for certain kinds of non-metallic materials such as glazes and glasses. Some materials which serve as indexes of this nature may, of course, be recognized without chemical investigation, although the application of chemical methods may make their recognition more certain. On the other hand, some kinds of materials which are indicative of cultural level are not easily recognized for what they are without chemical investigation. For example, the introduction of tin or lead into glazes, or the introduction of certain of the less common elements into glasses, represents technical advances which may be, and in fact frequently have been, overlooked in the study of ancient remains. An increase in the variety of materials utilized by a given people in the course of their existence may be taken as an indication of a rise in cultural development, and, conversely, a decrease may be taken as an indication of a decline.

It is probable that a rise or fall in the variety of the materials that was utilized is also, in general, an indication of a corresponding rise or fall in economic status, but a more direct indication of this may often be obtained through a chemical study of the particular kinds of objects that bear a direct relation to economic status, namely, the coins of a people. For example, in the early days of the Roman Empire the silver coins consisted of almost pure silver, but later the silver content of the coins underwent a slow but steady decrease that paralleled the increasing economic difficulties that occurred with the decline of the empire. Coins issued near the end of the long period of decline commonly contain less than ten per cent of silver.

The correct dating of ancient objects is a matter of great importance to the archaeologist, and though the chemical investigation of such objects does not appear to be generally useful for this purpose, it is useful for dating certain kinds of objects, especially in conjunction with archaeological evidence. For example, a rough chronological relationship has been found to exist between the chemical composition of ancient Greek bronze coins and the date of their issue. Coins of the earliest date generally contain a high proportion of tin and little or no lead. Somewhat later coins contain a lower proportion of tin and a moderate proportion of lead. The latest coins contain the lowest proportion of tin and a very high proportion of lead. This relationship between the chemical composition of the coinage alloy and its date of production has been successfully applied to the arrangement in chronological sequence of a number of types of the bronze coins of ancient Athens. Recently, a method has been found for dating ancient objects containing carbon, such as those made of cloth or wood. This depends upon the fact that the carbon incorporated into living matter at the time of its growth is noticeably radioactive in contrast to the inert carbon in inorganic matter such as limestone rock. This radioactivity is that of the carbon in the carbon dioxide in the atmosphere. When living matter dies, the radioactivity of its carbon begins to decrease very slowly and regularly, and by the measurement of its intensity at some later time the age of the former living matter may be estimated by calculation. This method is especially important for dating prehistoric remains, for often it is the only one that offers any degree of certainty.

A knowledge of the chemical composition of ancient objects is often useful for restoring or preserving such

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Most in Demand--Engineering Graduates!

• By Henry C. Woods
VICE-CHAIRMAN OF THE BOARD, SAHARA COAL COMPANY, CHICAGO, ILLINOIS

In a growing number of fields the demand for graduate engineers is becoming acute. This is especially true in the now mechanized coal industry which has much to offer the fledgling engineer since its emphasis shifted from unskilled labor to machines.

In this article the Chairman of the Vocational Training and Education Committee of the National Coal Association discusses the current situation. If he chooses the coal industry, the young engineer's career will be limited only by his ability, his application and his vision.

Jobs Aplenty

> The 430,000 students graduating from U. S. colleges this month are being sought out by employers, instead of having to job-hunt, a survey showed. Most in demand: engineering graduates.
> —*Quick* Magazine, June 18, 1951

That brief paragraph tells a big story. It issues a challenge to the educators of America and the students under their tutelage.

There simply are not enough graduate engineers to provide for America's needs!

Life Magazine in the June 25th, 1951, issue reports:

> Everywhere in the U. S. engineering firms are frantically bidding against each other for talent. Few graduates of reputable schools will start at less than $300 a month and some will make up to $500 a month; a senior at Illinois Institute of Technology this spring received no fewer than 17 job offers. Even with an increase in engineering enrollments, the supply is not expected to catch up with the demand until 1958 at the earliest.

Here is a great opportunity for the young men of America and the educational institutions that prepare them for the future.

Before we delve into reasons for the scarcity of engineering personnel, suppose we focus our light on the industrial picture itself. Let's see what industry has to offer the young man today; let's get a clear picture of what he might reasonably expect of the future.

Suppose we take any one of the 50,000 graduate engineers of last year's class— and *we can* take any one of them because all have found employment.

Because I am engaged in the coal business, and naturally know more about that industry than I do about any other, suppose we consider the case of just one of these young graduates, whom we'll call Sam Brown, and his association with the coal industry.

Fresh out of college, Sam was eager to get to work. With the shortage of mining engineers, plus the added demand made by a defense program, Sam found immediate employment with a large coal company. The work wasn't new to him because he had worked in a modern coal mine during his summer vacations. Many companies encourage this; it helps the undergraduate to "learn the ropes." It's a splendid way for a young man to equip himself beforehand with practical first-hand knowledge of the work to which he plans to devote his career.

Sam's starting pay of $300 per month was better than the average of all industry and from even his brief summer vacation periods, he could see that advancement was up to him, limited only by his own ambition and ability.

Sam didn't select the mining industry blindly. He looked over many, seeking primarily one that had a real future. He wanted to select an industry that was in the ascendency, not one that had reached its zenith or had seen its best days.

THE COLMOL CONTINUOUS MINING MACHINE—a new and revolutionary technological advancement in the method of producing deep mined coal. This machine continuously gouges out coal from a solid face without the need of the use of four ordinary mining machines which do under-cutting, drilling, shooting, and loading. The Colmol does all these things. It bores forward like a mole in the ground, gouging out coal faster than man has yet learned to get the coal produced away from the machine.

The Colmol moves steadily and continuously ahead in the solid coal without vibration, and can produce a 4-ton flow of coal per minute in a coal seam only 4 feet high.

NO MORE SHOVELING is done at the mines. Large automatic rubber wheeled loaders pick up the coal and put it on belts.

Here are the facts he learned that caused him to select the coal industry:

There is enough coal in the ground to last more than 2,000 years. He need not worry about the supply "running out."

Sam asked about the inroads that gas and oil were making on coal used for heat and power, and was told that the demand for coal has steadily increased through the years, despite the advent of other fuels; that new uses for coal were constantly being discovered.

Parenthetically, I might high-light here a forecast made by C. W. Connor, Director, Defense Solid Fuels Administration, to the members of the Rocky Mountain Mining Institute and published in the *Wall Street Journal* of June 8, 1951.

"Demand for coal can be expected to rise materially in the next few years," said Mr. Connor. He estimated the 1951 demand for coal at 630 million tons.

Mr. Connor broke down his 1951 estimate this way: 580 million tons of bituminous, compared with 1950's 512 million-ton production, and 50 million anthracite, compared with 1950's 44 million.

His estimate of the 1951 demand compared with the top producing year, 1947, which turned out 631 million tons of bituminous, only one million more than the total Mr. Connor believes is needed this year.

He points out that a big coal consumer with a growing appetite is the utility industry. Almost 90 per cent of the new electric plants scheduled to go into operation over the next few years are designed to burn coal, he said.

Supplementing Mr. Connor's remarks, it is important to note that more than half of our electricity is generated by power derived from bituminous coal. Without coal, our steel industry would shut down. Fifty per cent of the railroad traffic would grind to a halt. Cement mills depend on bituminous coal for 69 per cent of their fuel. Industry in general gets one-half its fuel supply from bituminous mines.

Sam Brown learned that the coal industry is really on its toes. Bituminous Coal Research, for example, was founded about 10 years ago by alert coal producers and millions of dollars have been spent in developing new uses for coal. BCR has made an intensive study of air pollution and the possible derivitives from coal. It is said that coal is used for 200,000 items of different kinds. You know many of them. The list embraces an almost infinite variety, including aspirin, the sulfas, anaesthetics, remedies for pain, and scores of other drug products; dyes, perfumes, plastics, fertilizing agents, moth-flakes, disinfectants, flavoring extracts and baking soda, to say nothing of nylon and countless other products.

New advances are being made in the application of power and heat as developed in the new type of railway locomotive, the amazingly improved new coal burning stoves and furnaces, and the numerous other inventions where coal is utilized as a basic fuel.

Engineers have learned how to extract the last ounce of energy out of the burning of coal for steam and electrical use and have developed equipment that has effected savings up to 60 per cent. In 1920 it took 3.0 pounds of coal to produce one kilowatt of power; now it requires but 1.19 pounds for each kilowatt!

Before he had become interested in the coal industry as a field for his life's work, Sam Brown had entertained some very erroneous ideas about it. The text book he used confused him, referring to conditions that had been obsolete for a generation or more.

Prior to his summer work in the mines, Sam had an idea that the old pick-and-shovel methods still prevailed, that sanitary and safety conditions left much to be desired. Instead, he learned that the industry is in the midst of a transfer from wholly hand-operated methods to complete mechanization. He discovered that today in 90 per cent of the mines, all coal is loaded by large electrical machines. Coal is drilled by electrical drills rather than by hand. Danger of explosions or catastrophies is avoided because the coal is shot down by permissible explosives and compressed air.

Mules are no longer used in modern mines. In many mines where electrical locomotives were formerly used to haul the coal in small pitcars, now some modern mines are using belt conveyors. Slopes instead of vertical shafts are used in many mining properties. Below ground the old open flame lights have made way for electric lights. For safety reasons, safety hats and steel-capped shoes are worn by the miners.

Millions of dollars have been spent in measures which have reduced accident rates to the level of other comparable industries, such as automobile and steel.

All this modernizing, all this improvement, all these mechanical short-cuts call for increased numbers of

experts and specialists. In short, there is a crying need for coal-mining engineers.

The picture looked rosy to Sam Brown. Then the thought occurred to him: *But what does the industry expect of me?*

First of all, Sam's employer expects that he will come equipped with a good 4-year college education, and that in addition to his major courses in mining, he will have a good understanding of English, mathematics, mechanics, electricity, chemistry, physics, geology and surveying. If he has had at least some introduction to the subject of labor relations, so much the better. The need for this today is quite clear.

The employer also hopes that, in addition to his summer work in the mines, Sam has been taught his strictly mining subjects by men who have had practical experience in the mines and who keep themselves well informed in regard to current methods by either summer work or by well-planned inspection trips.

But these are the "mechanics" of his training. What is expected of young Sam Brown as a *human being* who will be working with other human beings?

Are you dependable, Sam Brown? Can the folks you work for and with have confidence in you? If you have demonstrated that you can be depended on to be in the right place at the right time, with the right equipment, you will soon establish yourself as a welcome member of your organization.

The ability to "get along" in a friendly fashion with fellow-workers is another great asset which the young engineer will discover as his responsibilities increase and he takes on more important duties.

Sam's employer took it for granted that when he applied for work Sam was a mature man, that he had put away childish things. The employer expects Sam to continue to grow intellectually, and that he has a keen desire to move on to more responsible tasks when they are offered to him.

The employer greets with open arms the young engineer who will not take too much for granted, but will do some independent thinking. He should develop, for example, the ability to read a report and determine whether the subject is new or whether it is merely a description of an old method that has been superseded by something better.

It likewise shows mental growth if the graduate is agreeable to accept conditions that have been arrived at by sound experience rather than cling to something that seems better in theory.

Sam Brown joined the A. I. M. E. almost as soon as he entered the coal industry and his employer was well pleased. It indicated that the young engineer was interested in the mining industry as a whole, that he had more than a local outlook. Enlightenment was indicated.

It did not bother the young engineer to learn he was expected to do hard manual labor for a time. As a matter of fact, due to his summer work at the mine, he expected it. Rather than being disappointed, he welcomed it because the work would give him an understanding of the actual conditions of labor done by those he would work with. By familiarizing himself with their tasks through actually performing them, he knew he would gain his fellow-workers' confidence and respect; he would be better able to see that the operation is carried on in a safe and efficient manner.

Sam faces the future with confidence in his industry, his employer and himself. He knows the coal industry will endure throughout his lifetime, and for thousands of years after he has left the scene. He knows that science has merely scratched the surface in developing new uses for this magic mineral; that there are yet myriad miracles in a coal laboratory test tube. And finally, he knows his own future is limited only by his ability and his vision; the jobs of mine superintendent, manager, and top executive beckon to him. ●

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REFORESTATON OF STRIP-MINED land of the Sahara Coal Company, Harrisburg, Illinois. Millions of trees are planted each year.

Genetics and Evolution

• **By Edward J. Wenstrup, O.S.B., Ph.D.,** *(University of Pittsburgh)*
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Hereditary changes are constantly taking place, frequently in some forms, less frequently in others. Are these changes of sufficient magnitude to consider the products as new species?

The fact that taxonomists cannot agree on the answer is an indication that although evolution is still occurring before our eyes, the process is exceedingly slow. Geneticists will have to solve the problem.

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Evolution involves heredity and change. Lamarck accounted for the change but not for the heredity, Darwin for the survival of the fittest by natural selection but took the change, minor variations between parents and offspring, for granted. Any acceptable theory of evolution must take both into account, heredity and change. At first sight evolution may seem to involve a contradiction, for change or unlike is one requisite, while heredity insures the production of like. Change is necessary, and it must be of such a nature that it is transmissible, capable of being reproduced. Such changes in nature are rather infrequent and unpredictable.

Since the science of genetics studies the transmission of hereditary genes from one generation to another and also the means of altering the genetic makeup, it is the field that should eventually give us a solution of the problem of evolution, especially when combined with cytology.

Geneticists, outside the "Iron Curtain," place the hereditary units for the most part in the nucleus. There is some evidence for cytoplasmic inheritance, certain plastids, some of the early developmental stages due to maternal cytoplasm, and the Kappa substance found in paramecium. But the vast majority of cases show that the nucleus is responsible, or, more precisely, definite loci on the chromosomes of the nucleus. These loci contain the gene, and although the gene has never been seen with certainty, yet its reality is well established just as are the atom and molecule of the chemist, which are also too small to be visible.

The gene is a complex protein molecule, capable of reproducing itself each time the cell divides, so that all daughter cells have the same heredity. It produces a definite result during development, probably through a secretion produced by the gene. Should a change, a mutation, occur in this gene, it must still be able to reproduce the change, otherwise it would not be hereditary, there would be a gene missing in one of the daughter cells, and a double absence, one from each parent, would kill the organism.

Changes which occur in the chromosomes are of different types. They may be invisible gene mutations or various visible types of ploidy, translocation, inversions, duplications, fragmentation and union of chromosomes.

Gene mutations are changes in the chemical nature of the gene. These occur spontaneously in nature, but the causes are not yet completely known. They can be induced experimentally, especially by x-rays; ultraviolet light, heat, and mustard gas will produce similar changes, but not so abundantly. Many of the artificially produced mutations are similar to those occurring in nature, and the mutation rate may be speeded up 100 times or more by artificial means. The agent is not specific, that is, a definite agent will not produce a specific mutation, but any kind of mutation may arise; the change is not predictable. Most of the variations with which we are familiar in our domestic animals and plants are of this nature. The color, size, shape, productivity, etc., belong to this class. This type of mutation is responsible for most of the individual characteristics in man, those by which we distinguish one individual from another.

Besides gene mutations there may be more drastic changes by rearrangements of the genes on the chromosome. At times a section of the chromosome may be inverted, or a section duplicated or even lost.

A B C D E F G H I	A B H G F E D C I
Original	*Inversion*
A B C D B C D E F G H I	A B E F G H I
Duplication	*Deletion*

Whole chromosomes may be involved as in the following instances. Certain forms have been found with the haploid number of chromosomes, that is, the chromosomes are not paired, only a single set is present. Parthenogenesis in the *Hymenoptera* is such a case in which all the heredity of the sons comes from the mother's side. The unfertilized egg produces a male, and in its maturation process, there is an abortive cell division so that all the sperm contain a complete set of chromosomes as in other forms. The fertilized egg gives rise to a female in which the reduction is normal since she has the paired condition of all her chromosomes. In androgenesis all the heredity comes from the male side, a phenomenon usually due to an injury to the female pronucleus before fertilization. Except for natural haploids, all others are, for the most part, sterile.

Triploids result from the union of a diploid gamete with a normal haploid. Instead of paired chromosomes these are three complete sets. Triploids are usually sterile due to abnormal separation of the chromosomes at meiosis. Tetraploids contain four sets of chromosomes; if they belong to the same species they are called autotetraploids, if to different species, amphidiploids or allopolyploids. Many of these are interfertile

and may give rise to new races, eventually to different species. Higher multiples occur, especially in cultivated plants as in the roses, chrysanthemums and wheat.

When one or more of the chromosomes is single or triple, the condition is called heteroploidy. This is more frequent in plants than in animals in the wild state. Many of our cultivated fruits are of this type and are perpetuated by asexual means, i.e., by grafting. When sexual reproduction occurs in such forms the absence or double condition of one or more chromosomes causes the male gamete to be sterile. Such a condition in plants can be transmitted only through the female line and half of the offspring will be normal in each generation. As a result, the abnormal condition is gradually lost unless the new type should have some survival value over the normal plant.

These are the main changes which occur in the nucleus. How can they effect evolution? Let us take up each separately. Most of the gene mutations are deleterious and recessive. They have appeared frequently during the long period of existence of the wild species and have always been wiped out by natural selection. Occasionally mutations are useful, have survival value, and these are incorporated into the normal wild stock. One would, therefore, expect that any mutations which arise today would rather be of the harmful type since the advantageous ones have previously been made part of the genome of the species.

Whether gene mutations, in the strict sense, namely, point mutations, will eventually produce a new species is still debatable. All depends upon the definition of species, a point on which there is no agreement. A new mutation may be harmful in the original environment but useful in a new one. This would make for isolation of the new mutant, a condition necessary for the production of a new race, for constant interbreeding would eventually lead to the loss of the less favored allele. Repeated new mutations could produce a race so different phenotypically from the original that taxonomists would consider it a new species. When sexual isolation occurs, all would consider the new form a new species. For this to happen one would expect that some of the more drastic chromosomal changes would also accompany the gene mutation.

Inversions play an important part in the formation of races. This has been shown by Dobzhansky and his co-workers in *Drosophila pseudoobscura*. The genes on the salivary glands of the *Diptera* are labeled, so to speak, due to banding which appears on these chromosomes which may be 150 times the length of the ordinary mitotic or meiotic chromosomes, and composed of over 500 strings instead of just one or two chromonemata. Similar genes pair up in *somatic* cells, and this is especially evident in the salivary glands. Any inversions are at once evident cytologically. Loops will be formed, some simple, others compound, indicating at once how many inversions are involved, the length of each, and the location on the chromosome with exactness.

Unfortunately, these giant chromosomes are missing from other groups outside the *Diptera* so that this technique cannot be applied to them. There are 21 different arrangements of the 3rd chromosome of the races A and B of *D. pseudoobscura* and their relationships have been worked out, so that it is possible to determine how each strain was derived. Other chromosomes show rearrangements, especially the "X" and the 2nd, and crosses between the two races A and B produce sterile males but fertile females when back-crossed with males of either race. These strains are distributed in various localities in western U. S., some with a wide distribution, others restricted to small areas, and there is an overlapping in many places. One race is found only in California and Arizona, a second in New Mexico and Texas, and a third in all four states, but the relative numbers differ.

Some strains of *D. pseudoobscura* have a low viability in crowded conditions, others a higher survival value. Inbreeding for fifty generations has increased the viability, under similar conditions, in all but two of the seven, and x-rays have helped six of the seven stocks, though the majority of mutations produced in this way are harmful. The weaker individuals with harmful genes were lost in the crowded conditions and the stronger mutations survived, producing a sturdier stock. Even in the same locality variations in frequencies are found from month to month, showing that certain strains do better at one temperature or certain environmental conditions, others at lower or higher temperatures or different environmental changes.

Various chromosomal strains are found in plants as well. Blakeslee has studied the Jimsom weed, *Datura*. Although the various races have 12 chromosomes, these differ in translocations of segments of the chromosomes. These are not as readily detected, at least not the extent of the exchange, as they are in the *Diptera*, but they can be deciphered in hybrids at meiosis.

The various types of ploidy occur in nature and also have been induced experimentally with colchicine and other chemicals. Injury will at times produce a doubling of the chromosomes in the scar tissue and any shoots originating from this scar would be tetraploid. Just how important these changes are for the production of a new species is questionable. Sterile hybrids, the result of a cross between two different species, may be made fertile with chromosome duplication, and a number of such interspecific crosses have been made. Some natural species like corn and cotton are amphidiploids, i.e., a cross between two species with a consequent doubling of all the chromosomes. There is still some question regarding the ancestral stocks of corn and cotton, and more than two species may be involved.

Are these changes of sufficient magnitude to be considered as new species? All hinges upon the definition of species. At the turn of the century, there was a fairly common idea concerning species: fertility in offspring indicated the same species. But this would hold only for those forms with sexual reproduction. Asexually reproducing individuals would be different species and the two daughter cells from one bacterium would then belong to different species since they do

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Some Physical Factors Governing the Action of Electrons on Bacteria

• By Sister Maria Socorro, C.I.M.
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Although mutations in bacteria occur spontaneously, bombardment by slow electrons has been found to increase and hasten their frequency.

The work reported in this paper was done at Immaculata College under the direction of the Institutum Divi Thomae. It is part of an impressive research program, supported by the College and special grants, that has been conducted over the past six years.

In the study of the influence of electron bombardment on the heriditary mechanism of bacteria, pure cultures of staphylococcus aureus were used. The heriditary mechanism of an organism lies in the genes. The first step toward the production of a mutation is the absorption of a quantum of energy by some part of the chromosome in which are located these genes. If the genes are destroyed or altered in any way the characteristics of the cell are changed. Radiation, time, and temperature are the physical factors known to affect the frequency of mutation.

The energy of radiation is made up of small bundles or quanta which result from the slowing down of fast charged particles. Any system in the path of a charged particle undergoes a disturbance which may or may not bring it to its own level of activation. When a system absorbs an amount of energy that is known to give a certain reaction, that reaction does not always occur. Each bacterium in the neighborhood of the path of a charged particle absorbs a small fraction of energy which causes it to undergo a perturbation. According to the laws of probability which govern the action of radiation, all bacteria are not affected equally. It is a matter of chance, then, that some biological effects should take place.

Studies made by Wyckoff, Lea, and others, show that death or change in a bacterial cell is the result of a single hit or the absorption of a single quantum of energy in a vital structure of the cell. Lea and his coworkers suggest that these vital structures may correspond to genes and that death may be considered as lethal mutations. According to the one-hit-to-kill theory, the log of the survival ratio decreases linearly with respect to time of bombardment. Thus:

$$\log N/N_o = -kt$$

$$dN/dt = -kn$$

where k is a constant depending on the energy of the electron.

The following relationships were used to determine the energy of the electrons:

$$E_1 = \frac{(\text{accelerating voltage} - \text{retarding voltage}) \times e}{300}$$

where E_1 is the energy of the individual electrons striking the target and $e = 4.8 \times 10^{-10}$

$$E_2 = \frac{(\text{acceltg. voltg.} - \text{retrdg. voltg.}) \times I_g \times 10^7}{A}$$

where E_2 is the energy per second falling on a square centimeter of the target; I_g is the current in amperes read by the galvanometer; A is the area of the slit in the plates.

$$E_t = E_2 \times t$$

where E_t is the total energy falling on a square centimeter of the target; t is the time in seconds in which the electron current is allowed to flow.

In these experiments, mutations affecting color, biochemical characteristics, size and shape of colonies have been noticed after irradiation with a beam of slow electrons. The electron gun provides this beam. The three components of the gun are the filament, the plates, and the target. The filament is a spiral of tungsten wire which is coated with a mixture of barium and strontium oxides to emit a copious amount of electrons. This emission forms a cloud of zero velocity electrons about the filament. The electrons are attracted from this cloud by the positive accelerating plate, and travel in parallel lines due to the force field which is established between the zero and positive plate. The voltage between the filament must be maintained at a level sufficient to support a flow of current that will remain nearly constant. Therefore, in order to obtain electrons of energy lower than that imparted by the accelerating plate, a second plate is used to decelerate the electrons. The plates are so designed as to confine the electron beam to a definite area by means of a slit 9mm. × 1mm. in the plates.

The energy distribution of the electrons in the beam may be investigated by applying a retarding voltage between the target and the main housing. In this way a plot of retarding voltage and current will give the energy distribution curve. In a perfectly homogeneous beam, the theoretical energy distribution curve will be a straight line out to a value of retarding voltage equivalent to the energy of the beam of electrons.

The vacuum system consists of a mechanical pump in series with a two stage oil diffusion pump. The filament is operated from its own power supply. All remaining power is taken from a single source. The plate voltages are taken from slide wire resistors across the supply. The negative end of the supply is connected to the filament and the retarding voltage is

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Effects of Radiation on Heredity and Human Problems

• By **Albert Martin, Jr., Ph.D.,** *(University of Pittsburgh)*
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The killing of one-half of the world's population by atomic bombs would not put an end to civilization, but the vast numbers of mutations produced by irradiating even ten per cent of the people might well bring about the degeneration of not only our generation but of our species, and perhaps even the extinction of man.

The problem is man-made. We should utilize our superior intelligence to control with great strictness the use of radioactive materials. If this cannot be accomplished, we must prepare for the changes in our species,—physical, mental, social, and economic,—that are inevitable.

What will the future bring?

We, *Homo sapiens*, constitute a species that in a measure is in control of its own destiny. The possession of a free will sets us apart from all other living forms. The evolution of this will has in a large measure removed us from the rigors of natural selection, and in turn it places squarely upon us the responsibility for directing the course of our organic evolution. Only we, *Homo sapiens*, have any awareness of a past. Likewise, only we can recognize our present problems, and to some degree determine our future. It thus becomes our responsibility to use this awareness in directing the course of our own future and that of our species as well.

Scientific investigation has given us many tools. One of these, genetics, was conceived by the Austrian monk, Gregor Mendel, in 1865. The significance of his contribution to human thought and action is only now becoming apparent.

Genetics is the study of heredity, of why we are what we are, and what we can hope to do about it. It is true that the only way we could improve our own heredity is to have chosen our ancestors more wisely. It follows that what the next generation will be depends entirely upon those present in this one. What we as individuals pass on to our progeny determines at least the physical and mental quality of our species. What future man will be like, and even whether or not there will be future man, rests with those of our generation.

Certain characteristics of the new individual are established at conception. Once the union of male and female gamete has been achieved, the sex and the physical and mental potentialities of the individual are determined, and while they may be modified, they cannot be eliminated. These gametes that unite to form the new individual have no adult phenotypic characteristics, that is, no blood type, no skin color, and no emotional stability. The zygote, however, does develop, by means of a long series of complex transformations, into an organism which possesses, among other things, blood of a certain type, a more or less pigmented skin, and a certain degree of emotional stability. Furthermore, the traits or characteristics of an individual organism at any stage of its development are related to the traits of its parents and other ancestors; that is, everything an organism is and does is related directly or indirectly to its genes.

Changes in genes, or mutations, occur normally in nature. In fact, each extant species is a mutant based on some earlier standard. Left to nature, however, the aggregation of mutations in individuals is a relatively slow process. In the laboratory such changes may be brought about in a matter of weeks or months. Short wave radiations like x-rays, or ionizing particles such as alpha rays, beta rays, gamma rays, and fast moving neutrons bring about isomeric rearrangements within individual gene molecules. Breaks in chromosomes and various other chromosomal aberrations, such as deletions, translocations, and inversions of genes or chromosome segments occur. Some of these changes may be observed under the compound microscope, while others may be visible in the phenotype of a mutant individual or may be carried from one generation to the next as a recessive in the genotype. In the last analysis, every mutation is caused by some environmental influence.

Daily, all channels of communication remind us that we are living in the "Atomic Age." This phrase has different meanings for different people. For some, atomic research is a matter of academic interest; others are certain that the atomic bomb spells the end of our civilization; while still others deny that there are any lasting or far reaching effects of atomic radiation. This latter point of view was expressed in a press release dated the second of February, 1951, in *The Pittsburgh Press*.

> "Rochester, N. Y. Dr. Henry Blair announced that radio-active materials had been found in snow which has fallen there since the beginning of the Frenchman Flat tests. However, he said that there was 'no danger whatsoever to either animals or human beings.' He is the head of the atomic energy project at the University of Rochester."

Such a report as this is comforting but misleading, misleading because the frequency of mutation induced by radiation depends upon the total exposure and not upon how the dose is distributed in time. A given dose applied in the form of a very short intense treatment,

such as actual exposure to an atomic blast, will induce no more mutations than the same total dose when it is divided into a large number of parts, such as exposure to periodic x-ray treatments, fluoroscopic examinations, or radioactive snow. It follows then that the accumulation of radioactive materials in our environment is an active mutant-inducing agent of wide distribution and more or less permanent activity. There is now the definite need for the controlled use of radioactive materials. Uncontrolled, their genetic effect is enormous.

Very few scientific data on the effects of radioactive elements have been released for public consumption. In the laboratory, however, we see that some of these elements have rather drastic and far reaching consequences. Evidence is currently being accumulated which supports the hypothesis that exposure to sufficient quantities of beta radiation produces sterility, and that weaker dosages induce mutations and markedly increase the percentage of abnormal offspring. Radioactive phosphorus, for example, when administered to certain species of experimental animals steps up the occurrence of abnormal individuals in their progeny by 25 per cent, with some of these known to be inherited mutations. Certain members of ***Homo sapiens*** are being treated with radioactive phosphorus for physiological disorders. Experimental work on laboratory animals leaves no doubt that human beings receiving radioactive phosphorus to alleviate the symptoms of leukemia, for example, are exposing their germ plasm to an active mutant-inducing agent, and themselves to potential or certain sterility.

Such use of radioactive elements is already widespread. Experimental data support the warnings that from the genetic point of view a war using atomic energy, that is, the "A" or "H" bombs, would have more far-reaching effects than any previous war. Newspapers and magazines tell us otherwise, but the survivors of Hiroshima and Nagasaki have in all probability been so affected that their descendants will show many deviations from the normal. Some of these deviations may appear in the first generation and disappear within four or five; others will be recessive, and will appear only after several generations, with their effects continuing for hundreds of generations. The killing of one-third or one-half of civilized humanity by atomic bombs would not put an end to civilization, but the vast number of mutations produced by an irradiated ten per cent of civilized humanity might well bring about the degeneration of not only our civilization but our species, and even the extinction of our species.

We know from experience that most mutations occurring in any species are dysgenic according to present standards. Many such traits are recognizable today in the human germ plasm, aniridia, migraine, hemophilia, color-blindness, some types of feeblemindedness, and polydactyly to mention but a few. Each of these mutations occurred in the normal course of the evolution of our species. Under a system of natural selection many of the human beings possessing these dysgenic factors would have been unable to reproduce or to compete for survival with those possessing the so-called "wild-type" factors, and the dysgenic factors would in the course of time have been eliminated. Recurrent mutations would have occurred, but the percentage of dysgenic factors in any population would be low compared with our present situation, which has not been subject to natural selection; and even less when compared with what we can expect in the future.

Man, in foiling natural selection through the exercise of his free will and his mind, has fostered the accumulation of dysgenic factors in his species. Now he is in the process of speeding up the mutation rate through the use of actively radiating materials, with little or no thought as to the outcome. Since all individuals are equally likely to produce gametes in which mutations have occurred, only a few generations are needed for the appearance of these new genotypes in the homozygous condition. This delayed expression makes us more reckless with the causative agents than if their effects were immediate, more concentrated, and more conspicuous in their expression.

This is a problem that no generation will become greatly concerned about until it begins to affect personal individual freedom. Whatever else we may want our descendants to be, we would rather they would not be hemophilic, feebleminded, or spend their lives in mental institutions because of their emotional instability. We want them to be physically able to live in the world, to be emotionally stable, and to possess sufficient intelligence not only to maintain the status quo, but to advance the frontier of knowledge. Our ideals even now are not being realized.

At present, ten to fifteen per cent of our population are unable to maintain themselves in society on the basis of their dysgenic genotypes; these are the morons, the imbeciles, the idiots, and some of the hereditary physically-handicapped. Also, at present, one person out of every twenty in our population spends some time during his life in a mental institution. This, of course, is not due entirely to heredity, but emotional stability is inherited, and the possessors of many genotypes are not capable of continuous stable reaction in our present environment.

Then too, there is the problem of the sex ratio. This problem has its environmental side, but sex is determined genotypically. If we allow all factors to continue to operate as they are doing at present, by the year 2000 the population will contain at least three females of marriageable age for each male of that age group, as compared with a ratio of three females to two males at the present time. We have considered that there is an equal chance for an X-bearing sperm and a Y-bearing sperm to fertilize an egg. Theoretically this is so, but what in the past has disturbed this ratio. and what does the future hold in the light of our increasing the frequency of gene mutation? The 1950 census indicates that the population of the United States increased 15 per cent since 1940, an increase of 19,000,000 persons, or an increase of 216 persons for each hour that passed. If this present rate continues, by the year 2050 approximately 300,000,000 people will

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The Truth About the Lie Detector

• By John E. Reid
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This authoritative article explains how lying is detected by the use of instruments.

The writer, a member of the Chicago Bar, was formerly chief polygraph examiner at the Chicago Police Scientific Crime Detection Laboratory. He is now actively engaged in scientific personnel investigations as Director of John E. Reid and Associates. He is the inventor of a muscular movement recorder which is used in his own instrument, the Reid polygraph, along with other units that record blood pressure, pulse, respiration, and electrodermal response.

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Most of us have at some time thought to ourselves "that man is lying to me." We have on these occasions functioned as our own "Lie Detector." We remember how the other person acts and talks, and now we question him and note that he cannot look us in the eye and that his answers are evasive. In other words, we have by observation picked up external or objective changes upon which, rightly or wrongly, we base our opinion. The difficulty is that the practiced liar usually can control his outward appearance and therefore may fool us.

Scientific lie detection is based upon the same basic principles as observational lie detection. The main difference is, however, that by means of an instrument and a questioning technique physiological reactions are graphically recorded, and the recordings are of changes over which the subject has little or no control. By comparing the difference, if any, in the recorded reactions on known, truthful questions with the recorded reactions to pertinent questions regarding the crime, it is concluded whether the subject is either lying or telling the truth.

The Instrument

The most dependable physiological recordings in lie detection are the blood pressure-pulse and respiration recordings. The blood pressure-pulse recordings are obtained by attaching a blood pressure cuff to the arm. One end of a length of small diameter rubber tubing is joined to the cuff; the other end is attached to an actuating bellows in the instrument, forming a sealed air system. An inflator bulb is used to introduce approximately 90 mm. of mercury air pressure into the system, which pressure equalizes itself in the cuff and in the actuating bellows. The fluctuations in the subject's arm due to the action of the heart and the changes in blood pressure cause an increase or decrease in pressure within the cuff and in the actuating bellows. These blood pressure-pulse changes are recorded on an electrically driven chart geared to travel at the rate of six inches per minute.

The respiration or breathing is recorded substantially in the same manner as the blood pressure-pulse. The pneumograph tube (a corrugated rubber tube sealed at one end and open on the other, 12" long by 1½" diameter) is fastened around the subject's chest. A length of small diameter rubber tubing attached to the open end of the pneumograph tube and then connected to the actuating bellows in the instrument completes the sealed-in air circuit. Unlike the blood pressure system, additional air need not be introduced because the dead air in the system itself is sufficient to produce the desired recording results. When the subject inhales, the pneumograph tube stretches and draws the air out of the actuating bellows in the instrument, thereby changing the position of the pen on the chart. Exhaling returns the pen to its normal baseline.

The only electrical recording on the lie-detector is the psycho-galvanic skin reflex. This recording is obtained by attaching electrodes to the hand and passing an imperceptible amount of electric current through the hand. Variations in the flow of the electric current are produced by the quantity of perspiration in the palm of the hand.

In the writer's own instrument (the Reid Polygraph), muscular movements are recorded from the chair upon which the subject sits, in a mechanical manner similar to that used in recording the respiration. Sturdy bellows are hooked to the chair arm rests and to the chair seat under the thighs. Three separate lengths of rubber tubing connect the bellows in the arm rests and chair seat to three actuating bellows in the instrument. Muscular pressure, regardless of the amount exerted by the subject's arms or legs during the tests, is simultaneously recorded by air displacement with the blood pressure-pulse, respiration and electrodermal response. Any efforts on the part of the subject to "beat the machine" by secret muscular movements are readily detected by this means.

The Questioning Technique

The test questions are prepared and discussed with the subject beforehand and worded so that they can be answered by either "yes" or "no." When these questions are asked on the test itself, fifteen-second intervals are allowed between the asking of the questions to permit the instrument time to record the reactions. Only nine questions are used in each test because further questioning would cause discomfort occasioned by the tightness of the blood pressure cuff. The first two questions are irrelevant but deal with facts which the examiner knows to be true, such as: "Do

(Continued on Page 135)

Carbon Black

• By Hanna Friedenstein
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The term carbon black denotes a group of industrial carbons used chiefly as reinforcing agents in rubber and as pigments in inks and paints.

Largely because of their extreme fineness, carbon blacks have unique properties in many industrial applications.

This paper is a brief account of methods of manufacture and properties of these carbons, and particularly of their use in rubber.

In 1950, factories in the United States made well over one billion pounds of carbon black, over 90 per cent of the total world supply. This was 13 per cent more than in 1949 and two hundred times the amount produced in 1918. More than 90 per cent of all the carbon black made is used by the rubber industry. About 5 per cent is used as a pigment in inks, paints, lacquers and similar compositions. The remainder finds use as pigment in such materials as paper, carbon paper, typewriter ribbons, plastics, phonograph records, shoe polishes, leather coatings and colored concrete; as an absorbent and fuel in the preparation of liquid oxygen explosives; and as an electric conductor in dry cells. But the main customer of the carbon black manufacturer is the rubber industry, which depends on carbon black to toughen its products, and particularly to impart good wearing qualities to tires.

Crude rubber is a soft, tacky material, with none of the properties we expect in most rubber goods. These qualities are imparted to rubber by mixing it with a number of other ingredients, then working the mixture into the desired article and finally "vulcanizing" it. It is during the vulcanization or "curing" step that the rubber acquires the strength and elasticity required in the finished product. The stiffness and strength of vulcanized rubber, and particularly its resistance to abrasion, cutting and tearing, are vastly increased by inclusion of carbon black among the compounding ingredients. This is what we mean by "reinforcement." Other materials also possess reinforcing ability, but as yet none have been developed which approach carbon black in reinforcement. Without carbon black, a passenger tire-tread would wear out after about 3,000 miles, whereas a modern tire-tread reinforced with carbon black, has a roadwear of some 30,000 miles.

Chemically nothing but nearly pure carbon, carbon black owes its unique rubber toughening or reinforcing properties largely to its extreme fineness. Carbon black particles range in diameter from 50 to 5,000 Angstrom units ($1\text{Å} = 10^{-8}$ cm). Such fine particles can not be made by simply grinding coarser forms of carbon such as coal or coke.

Carbon black is made by the decomposition of hydrocarbons. The soot formed in the flame of a wax-candle or of a Bunsen burner with limited air-supply is a form of carbon black; it may be collected by placing a cool surface into the upper section of the flame. This is exactly the principle of the so-called "channel process" of making carbon black. In commercial manufacture, millions of flames of natural gas are burning in long hot-houses. (Fig. 1.) The air-supply is controlled by dampers or vents, so as to ensure that combustion is always incomplete. Under conditions of complete combustion, the hydrocarbon would burn completely to form carbon dioxide and water vapor, and no carbon would be obtained. The exact mechanism of the production of carbon black is still puzzling the experts, but the principal chemical reactions taking place in the channel process may be represented by the equations:

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O + \triangle$$
$$CH_4 + \triangle_1 \rightarrow C + 2H_2$$
$$2\,H_2 + O_2 + \triangle_2 \rightarrow 2\,H_2O$$

where $\triangle$, $\triangle_1$, and $\triangle_2$ represent the heats of reaction. The channel process derives its name from the iron channels on which the black formed in the flames is deposited.

The quality of the carbon black produced can be changed by varying the shape of the flame, the distance

FIGURE 1. Inside a channel black "hot house."

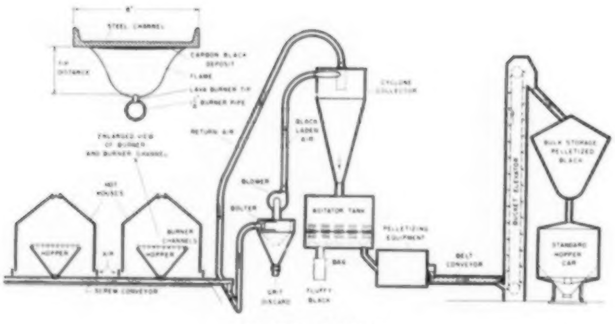


FIGURE 2. Carbon black by the "channel" process.

of the burner tip from the collecting channel and the carbon content of the fuel. The black is removed from the slowly moving channels by fixed scrapers, from which it falls into hoppers, and is then carried in pipes by screw conveyors to the packing house. (Fig. 2.)

Until 1941, channel blacks constituted about 90 per cent of the total amount of carbon black produced; today, they amount to less than 50 per cent. They are used extensively both in the rubber industry and as "color blacks" in inks, paints, varnishes, etc. Rubber blacks have been classified according to their ease of mixing in rubber. The various types are designated as EPC (easy processing), MPC (medium processing), HPC (hard processing), and CC (conductive).

The average particle size of the rubber blacks ranges from 300 Å for EPC blacks down to 200 Å for CC blacks. As the particle size decreases the blacks become more reinforcing but at the same time more difficult to process in rubber. The finer blacks (down to 50 Å), known as "color blacks," are used as pigments whenever blackness is required, e.g. in synthetic enamels, paints, lacquers and plastics. The finer the particles, the "blacker" the black. The coarser grades of color blacks (250 Å) also find extensive use in news inks and black paper. Special "long-flow" channel blacks are used in lithographic and half-tone inks, carbon paper and typewriter ribbons.

Blacks 200-700 Angstroms in diameter have been made by the "furnace process" which, just as the channel process, consists essentially of the partial combustion of hydrocarbons. The combustion now takes place not in millions of small flames, but in one large flame arising from a multiple burner and confined in a furnace. The household oil burner is a potential miniature plant for making furnace black. Of course, it is normally adjusted for complete combustion, so as to produce heat and not soot. However, if the air supply is cut down, an ordinary oil burner will produce carbon which is actually a rather coarse grade of furnace black.

In the furnace process, both natural gas and oil may be used as fuel, either separately or in combination. The quality of the black produced can be changed by varying burner and furnace design, type of fuel and air-fuel ratio. Since, contrary to the channel process, there is now no cool channel to collect the black directly from the flame, the black emerges from the furnace together with the gaseous combustion products, in the form of smoke. After the gas-stream has been cooled by water sprays, the black is agglomerated into loose aggregates by electrical precipitators and finally separated from the gas-stream by cyclone collectors. (Fig. 3.) In this state, the black is very light and fluffy, with an apparent density of about 5 lbs./cu. ft. For ease of handling, it is usually compacted to the "pelletized" form which has an apparent density of 25 lbs./cu. ft.

Furnace blacks are generally classified according to their behavior in rubber, into semi-reinforcing (SRF), high-modulus (HMF), fine (FF), fast extrusion (FEF) and high abrasion furnace blacks (HAF). They are used extensively in synthetic rubber treads and tire carcass, in mechanical rubber goods, rubber hose, footwear, etc. The greatest reinforcement, surpassing that of easy processing channel blacks, is obtained with HAF blacks. As their name indicates, they are characterized by the high resistance to abrasive wear which they impart to all types of rubber. The "FEF" blacks give exceptionally fast extruding and smooth appearing rubber stocks.

HAF and FEF blacks are made from oil; they differ from furnace blacks made from natural gas, particularly in a characteristic known as "high structure" which is the tendency observable under the electron microscope, to line up in long, chain like aggregates. Acetylene black shows this tendency to an even higher degree. Channel and furnace blacks made from natural gas exhibit "normal" structure, i.e., have little apparent tendency towards chain-formation. This property of "structure" is associated with some of the unusual properties of certain blacks in rubber.

A third form of carbon black, known as thermal black, is produced by thermal "cracking" of natural gas. In this case, the gas is heated to its decomposition temperature to yield carbon and hydrogen:

$$CH_4 + \triangle \longrightarrow C + 2\,H_2$$

where $\triangle$ is the amount of heat required. The production of thermal black is an intermittent two-stage process. An insulated furnace, filled with a checkerwork of fire brick, is first heated to 900-1400°C by firing it with air and gas in proportions for complete

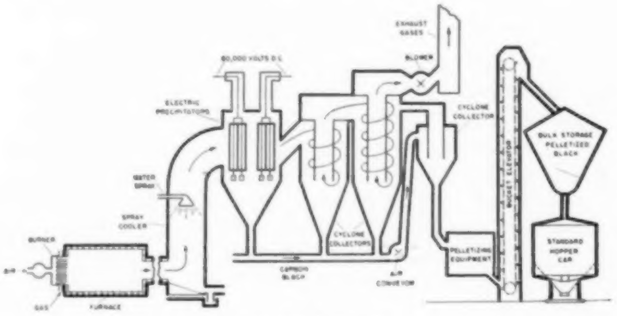
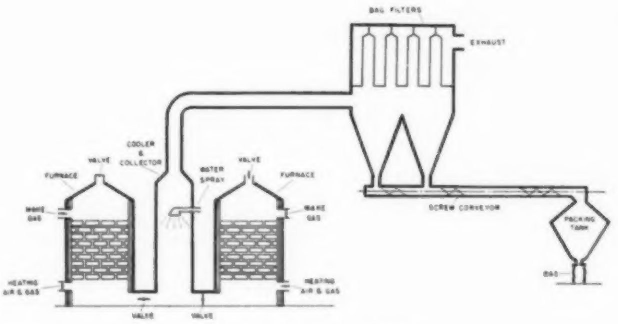


FIGURE 3. Outline of the "furnace" process for making carbon black.



THERMAL PROCESS

FIGURE 4. Making carbon black by the "thermal" process.

combustion. Then the "heat" cycle is interrupted and the furnace is charged with gas only, which decomposes. The black suspended in the off-gases (largely hydrogen) is passed through water spray towers and eventually collected in cloth bag filters. The blacks produced, known as "medium thermal blacks," are the coarsest of the carbon blacks, averaging 4000 to 5000Å in diameter. By proper dilution of the natural gas in the "make" cycle with spent flue gases, "fine thermal blacks" are produced, with an average particle diameter of 1200-2000Å. (Fig. 4.)

Thermal blacks constitute only a small proportion of total carbon black production (about 7 per cent). As is to be expected from their particle size, thermal blacks have negligible reinforcing effect in rubber. They have a unique function as rubber fillers, however, since they can be used at very high loadings, with a minimum stiffening of the rubber stock or loss in elastic properties. Their main use is in mechanical rubber goods. The "fine thermal" blacks are also used in inner tubes.

An entirely different type of carbon black is produced when an endothermic hydrocarbon, such as acetylene, is decomposed into its elements. The decomposition of acetylene takes place at about 800°C according to the reaction:

$$C_2H_2 \longrightarrow 2\,C + H_2 + \Delta$$

This reaction is strongly exothermic and part of the heat liberated is utilized to maintain the reaction. The black is collected from the bottom of the retort and is compressed to varying degrees. Acetylene black has an average particle diameter of about 500 Å. Its outstanding properties are high electrical conductivity and "super structure", which make it unique as a filler in dry cells and for rubber products wherever high electrical conductivity is required.

While particle size and structure are the most important fundamental properties of carbon black which determine its behavior in rubber and in other applications, there are other characteristics which also have an important effect. One of these is the chemical composition and amount of volatile matter adsorbed on the surface of the black. In the channel process, the black, while still hot, is taken out of the protective reducing atmosphere of the flame by the movement of the channel irons toward the collecting hoppers. Oxidation takes place on the surface of the carbon particles and the chemi-sorbed oxygen is present as carbon-oxygen complexes of acidic nature, which are responsible for the hydrophilic characteristics of channel blacks. Furnace blacks, on the other hand, which are not subjected to oxidizing conditions during manufacture, contain only small amounts of chemically combined oxygen, and have neutral or basic properties.

This difference is of great importance in rubber compounding, since acidic materials are well known retarders of vulcanization. The channel blacks retard the rate of vulcanization or "cure" while the furnace blacks have much less effect on the curing process. While this causes no serious difficulties in synthetic rubber, natural rubber reinforced with furnace blacks shows a serious tendency to premature vulcanization, generally referred to as "scorch."

Furnace blacks really came into their own only during World War II, when natural rubber was scarce and synthetic rubber sales rose abruptly from 20 million pounds in 1941 to almost two billion pounds in 1946. During the same period, furnace black production rose from 100 million to over 600 million pounds. At the same time, total carbon black consumption by the rubber industry more than tripled in volume, partly because synthetic rubber requires much greater loadings of carbon black for reinforcement than natural rubber. Even today, the amount of carbon black used per pound of rubber is substantially greater than before the war, mainly because of the substantial use of synthetic rubber. Properly reinforced, synthetic rubbers have road wear qualities equal and even superior to natural rubber. But the new synthetic rubbers would be virtually useless without the special carbon blacks designed to reinforce them. "Cold rubber" tire treads, for instance, owe much of their exceptional road wear qualities to the development of HAF blacks.

Thus, new blacks are continually being developed to meet the changing needs of the consumer industries. Production methods are being improved and research is underway to enable us to understand better the fundamental reasons for the behavior of carbon blacks in various applications.

Thanks are due to Godfrey L. Cabot, Inc., for permission to publish this paper and for supplying the illustrations. ●

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"The modern conception of learning envisages pupils attacking and studying problems of recognized importance, interacting continuously with the social and physical environment and utilizing whatever resources will aid in the solution of their problems. Pupils will feel the need of doing these things outside the schoolroom and beyond school hours, including work similar to the more intelligent type of home assignments of some years ago."

—WILLIAM H. BURTON
Harvard University

Stretching the Physics Budget

• By Eugene A. McGinnis
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In recent years science budgets have not kept pace with rising prices. Sometimes, laboratory equipment that is desired and even actually needed, cannot be purchased.

But a number of kinds of apparatus can be constructed from odds and ends by an ingenious and enthusiastic teacher.

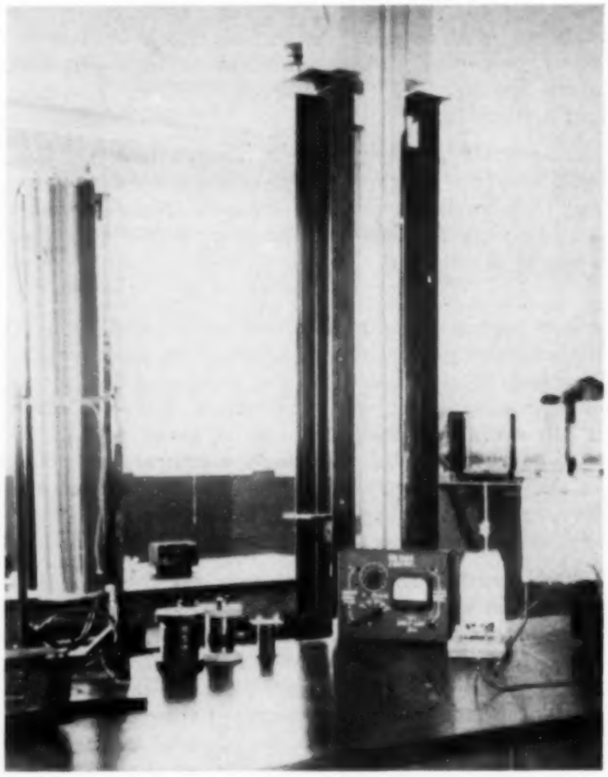
Here is a brief story of how the Sears Roebuck Company, the junk man, and the radio supply house helped one college instructor solve the problem of a shrinking departmental budget.

The main idea of this paper is not to present any new and promising scientific data, but rather to suggest means of stretching that ever-decreasing physics budget. Many of you, no doubt, now have your heart set on obtaining some expensive piece of equipment for your advanced laboratories, such as a Michaelson's interferometer or a spectograph, but you must needs postpone its purchase because of the high cost of replacing some of the elementary equipment that has been damaged or has worn out. We have been able to construct some of our elementary laboratory equipment on the premises with a minimum of work and with a surprisingly small cash outlay. Here are a few of the ideas that have saved us considerable money on elementary equipment during the last few years.

One that is economical and at the same time instructive for the elementary laboratory is an apparatus for measuring the Young's modulus of samples of wire. It was constructed from scrap construction steel that we picked up at a junkyard. After scraping off the rust and painting it a laboratory black we assembled the steel into a very rugged and serviceable frame to which we attached our wire and measuring device. The total cost of making six of these frames was under $20.00, which when compared to the present market price of about $50.00 each for a similar piece of equipment is a good indication of the saving made possible by homemade equipment. We were very busy at the time we made these, so they are much cruder than they need be. The angle iron was cut with an acetylene torch rather than with a hacksaw and the edges are ragged. The apparatus is serviceable, however, and has given very good results.

Providing a means of clamping the wire proved to be troublesome until we had the idea of improvising with a 5-cent bolt that we purchased from Sears, Roebuck. These bolts were drilled along the axis part of the way, and then carefully in at an angle through the threads so that the wire can be fed through the bolt and the nut backed off until it clamps the wire securely. This clamping device proved not only usable but better than any of the ones we have yet encountered on purchased equipment.

Another particularly useful device for more reasons than one has been a voltage divider that we built from war surplus meters, surplus wafer switches, and several 10,000 ohm, 10-watt resistors obtained at a local radio supply house. This device has the advantage of making one power supply do the work of several, and at the same time it instructs the student who uses it. It is of standard design except for the switching arrangement which switches out one of the 10,000 ohm resistors and switches in a similarly rated potentiometer at the particular place in the array of resistors to give the voltage desired. The switched in potentiometer gives a most satisfactory technique for controlling the output voltage as finely as desired. These voltage dividers have proven so valuable that we have constructed several and have plans for making more. They can be made very compact and need not have a high wattage rating unless it is desired. We have also found that the wiring of the switches provides a very good experiment for a student in applied electricity.



VOLTAGE DIVIDER made largely from war surplus materials.

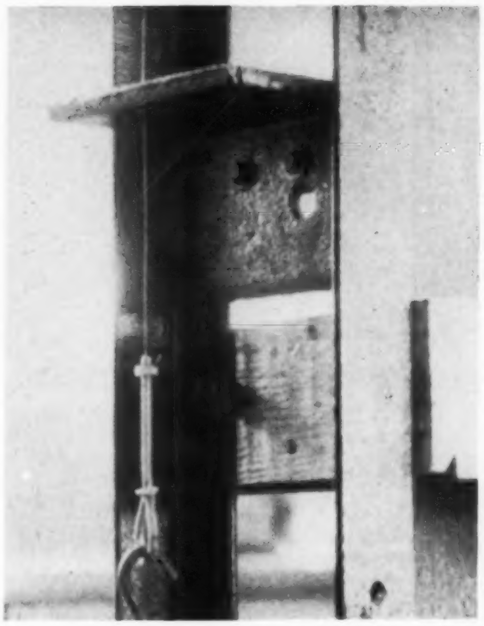
During the early part of the year we decided that it might be a good idea to stress electronics as part of the physics curriculum. It seemed especially desirable because a large Army Signal Corps Depot is to be located in our community. It could use the services of some of our students if they were adequately trained. Even though we were reasonably well equipped for the electronics connected with our regular electricity course, we found that we could not conduct a course in electronics that would be worthy of the name without expending almost our entire departmental budget on special equipment. Rather grudgingly we decided to invest some $30.00 in a radio board consisting of tube sockets, terminals, and separate stencils, which would tell the student how to hook wires from one terminal to the other so that even the most elementary student would be able to wire a simple amplifier or tuning circuit. When the apparatus arrived and we saw what we had paid so much money for, we decided that we could easily make as serviceable, though not as attractive a board, for only a fraction of the cost. As a matter of fact we have since found that a simpler board consisting of an octal socket and eight terminals spaced symmetrically around the socket is not only easier and more economical to construct but much more instructive to the student. It is especially versatile inasmuch as several can be connected together to make up a more intricate circuit.

It was during the episode of the radio boards that we discovered that college students are indeed little boys, and that Tom Sawyer's fence-painting psychology still works. When the students saw their teachers exhibiting great mechanical ineptness, particularly when it came to painting the boards, they were ready if not anxious to suggest a better way of doing the job. Before they realized what had happened the students were supplied with paint and brushes. They did a fine job.

In constructing equipment we have had occasion to meet quite a few junk dealers. They are very nice people. In several instances they have given us gratis old pieces of iron with which we made physical pendulums and the like. Someday, perhaps, we shall find that we have inspired one of them to endow the University with a new physics laboratory. All junk dealers are said to be notoriously wealthy!

There is a lot of fun in making your own equipment. We have found new uses for substances that their manufacturer never dreamed of. For instance, we have found that ordinary wall-patching plaster is ideal for making molds for casting lead and other metals. It is especially easily worked, hardens quite readily, and when almost hard can still be shaped easily with a pocket knife to the required contours and dimensions. Using scraps of lead that we had lying around the place we made a useful lead shield for a scaler project. It fulfills its purpose very well and cost almost nothing.

Another substance that the amateur can easily work into almost any shape is asbestos cement. We have made several insulated devices with it. In one particular case we needed an apparatus to show the characteristics of a black body. We made the black body



HOME-MADE APPARATUS for measuring the Young's modulus of wires.

by taking an ordinary toilet bowl float, snipping it apart at the seams with a pair of tin snips, painting the interior black, and soldering it together again. The float was then suspended in a gallon Zerone can, which was covered with a thick layer of asbestos cement. The apparatus, though crude, really works. Even though the results it gives are not too accurate, they are at least indicative.

In making your own equipment you will find a well equipped work shop very useful. At first, equipping a shop might appear to be expensive, but one can usually obtain second hand equipment at very low prices. A lathe that will merely revolve will be plenty accurate enough for winding coils. We were fortunate enough to pick one up a few years ago. It has paid for itself by winding coils alone, besides being very useful in other ways. To give an idea of how much can be saved in this manner: supply companies list an induction coil, 150 milli-henries, at $16.50; we have wound *seven* induction coils ranging from 100 to 300 milli-henries at a total cost for wire of $20.00. On this one item alone we have saved enough to buy two second-hand drill presses.

These are only a few of the items that we have made ourselves that have proven to be not only useful but economical. No doubt many of you have had similar experiences in your laboratories. We would especially like to share ideas with anyone who is similarly interested. ●

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NEW BOOKS

General Chemistry

• *By* WILLIAM A. FELSING and GEORGE W. WATT. Third edition. New York. McGraw-Hill Book Co., Inc. 1951. Pp. x + 558. $5.00.

The third edition of this estimable college textbook places greater emphasis on fundamental principles than on descriptive and factual matter. In this and in other ways the new edition is an improvement over the earlier editions. Those who use it will approve these and other important changes, and the increased stress on the quantitative aspects of chemistry. The study of atomic structure comes in an early chapter but nuclear chemistry is not considered until late in the book. The periodic classification of the elements is discussed in Chapter 16. Four chapters on organic chemistry constitute the final chapters. The exercises and problems that appear at the end of each chapter are well done. Students will be glad that answers to the problems have been provided. The book is exceptionally well designed and made.

H. C. M.

Community Health Education In Action

• *By* RAYMOND S. PATTERSON and BERYL J. ROBERTS. St. Louis: C. V. Mosby Co. 1951. Pp. 346. $4.50.

Anyone engaged in health education, specialist or layman, will be interested in this excellent book. Reading it will not only give information and assistance and pleasure, but also at times considerable amusement. It is based on wide experience. The authors have traveled the road. Methods of doing things are explained and definite warnings are given when necessary. The school health instruction program is not discussed, but the teacher will find here many valuable suggestions.

The problems and procedures involved in community organization for public health are discussed fully. The worker is told how to speak and write effectively, how to prepare letters, circulars, and booklets, and how to make an annual report. He learns how to construct interest-compelling exhibits that put across a message, and how to get newspaper, radio, and television publicity. Written in an intimate readable style, this book should be put in the hands of every health educator, especially any who may be inclined to be a bit pompous.

H. C. M.

Exhibit Techniques

• *By* HELEN MILES DAVIS, Editor. Washington, D. C.: Science Service. 1951. Pp. 112. $2.00.

This compact volume is recommended as one of the most practical helps of its kind the reviewer has seen. Anyone, teacher, student, or club sponsor who must plan a science display for a science fair, a show window, a science club, a school open house or other occasion, will find valuable assistance in this little book. How to plan the exhibit, safe construction, action displays, lettering and labels, electrical rules and other ideas that will save time, energy, and money for the exhibitor are discussed in a simple, straightforward manner. Dioramas, illusion boxes, the use of stroboscopic light, star projectors, taxidermy, and molded displays all receive attention. Criteria for judging the completed display or project are considered. Twenty-four student winners in recent Science Talent Searches tell how they constructed their successful displays. This feature is much more valuable than the final section on home laboratory hints. These would seem to be of doubtful value if the book is to be used by high school pupils.

H. C. M.

Atomic Energy in War and Peace

• *By* CAPT. BURR W. LEYSON. New York: E. P. Dutton & Co., Inc. 1951. Pp. 217. $3.75.

A valuable and interesting addition to the high school or home library from the pen of a prolific and respected writer of articles and books dealing with science and aviation. Written for the non-science layman and as supplementary reading for the high school science class, this book contains a wealth of information about atomic energy and its applications. The author describes in non-technical terms the production of fissionable materials, the atomic and hydrogen bombs and their effects, and methods of defending against them. Devices and instruments for the detection of radiation are discussed. There are brief descriptions of the cyclotron, betatron, cosmotron and other particle accelerators, and their value in research is considered. The final chapter is devoted to the applications of atomic energy in medicine and industry. There are numerous illustrations and tables and a glossary of terms.

H. C. M.

200 Miles Up

• By J. GORDON VAETH. New York: The Ronald Press Co. 1951. Pp. XIII + 207. $4.50.

This book deals with modern atmospheric research, rocketry, and ballooning, and man's attempts to conquer the upper air. Air-minded readers will be glad to learn how rockets are built and fueled and launched, and what was accomplished by the firing of the German rockets captured in World War II, and the powerful American rockets as well. Here is told the truth about the plastic balloons that convinced so many observers that "flying saucers" are a reality.

In a brief space Mr. Vaeth gives a factual summary of what scientists have been able to learn through air-borne instruments of the nature of the atmosphere at elevations far beyond the reach of piloted vehicles. His account will interest physicists, aerologists, engineers, and technicians, as well as laymen. Put this book on your reading list.

H. C. M.

No Woman's Country

• *By* MICHAEL LANGLEY. New York: Philosophical Library, Inc. 1951. Pp. 221. $4.50.

This book would be worth reading merely as a story of travel in the Anglo-Egyptian Sudan even if it did not give such a wealth of worth while information concerning this little known region and the habits and customs of its people. Mr. Langley's account is interesting, factual and circumstantial, perhaps at times too circumstantial for some readers who will question the desirability of including detailed descriptions of certain tribal customs.

There are 58 illustrations of the author's own making, selected from the many he obtained on his 10,000-mile, 9-month journey that covered a million square miles of territory. At the story's end the attentive reader will have a far better appreciation of the nature and the extent of the Anglo-Egyptian Sudan, and of the contribution Britain has made to its development.

H. C. M.

Inorganic Semimicro Qualitative Analysis

• *By* CARROLL W. GRIFFIN, Ph.D., Professor of Chemistry, and MARY ALYS PLUNKETT, Ph.D., Assistant Professor of Chemistry, Vassar College. The Blakiston Company, Philadelphia. 1951. Pp. x + 299. $4.75.

It is a distinct pleasure to review a book with which one does not feel the necessity of taking serious issue with the coverage, presentation, or accuracy. This volume seems to have been prepared with unusual care and, probably for that reason, its aim has been well realized. This aim, in the words of the preface, is "to teach the underlying principles of analysis which may be applied to any future undertaking of an analytical nature, and to develop in the student a method of execution which is sure because it is based upon precepts which are clearly understood and techniques which are cleanly performed."

The treatment is divided into a theoretical and an experimental part. In the theoretical part, atomic and molecular structure, electrolyte theory, equilibrium theory, complex ions, and oxidation-reduction are treated, adequately but not too intensively, with numerous analogies and illustrations. The experimental part includes information and exercises of the usual type on the conventional selection of cations and anions. No systematic separation of the anions is attempted. All procedures appear to be clearly described and sufficiently detailed for successful laboratory work.

If a reviewer does not find *something* to quibble about it may be suspected that he has not read very extensively. Aside from the spelling "neutrinoes" (page 3) the quibbling in the present case would involve primarily the formulas that are used to represent various chemical entities. Perchromic acid, for example, is probably better represented as H_2CrO_5 than as H_3CrO_7 (page 222) (see Nicholson, *J. Am. Chem. Soc.* 58, 2525[1936]). Similarly, the ferric thiocyanate ion is probably $Fe(CNS)^{++}$ rather than $Fe(CNS)_6^{---}$ (see Edmonds and Birnbaum, *J. Am. Chem. Soc.* 63, 1417[1941]). Finally, in the example (page 151) illustrating the use of $KMnO_4$ as an oxidizing agent, it would be preferable to use $FeSO_4$ instead of $FeCl_2$, since chloride is normally oxidized by permanganate.

The printing is excellent and the proofreading apparently flawless; not a single misprint was detected. The volume is sturdily and attractively bound. This book is recommended to all teachers of the subject as among the best in the field.

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Duquesne University

On the Origin of Species

• *By* CHARLES DARWIN. New York: Philosophical Library. 1951. Pp. XX + 426. $3.75.

This is the first unexpurgated reprint of the original edition of Darwin's work published in 1895. Here, except for punctuation, is the discussion exactly as it was written. Coming at a time when Darwinism and its interpretation are still the center of much controversy this reprint gives laymen and scientists a welcome opportunity to learn what Darwin actually said in his original paper. C. R. Darlington, F.R.S., wrote the scholarly foreword.

H. C. M.

The New Physics

• *By* SIR C. V. RAMAN. New York: Philosophical Library. 1951. Pp. 144. $3.75.

Not long ago Sir C. V. Raman, India's most famous physicist (Raman effect), and one of the world's great scientists, Nobel Prize recipient, and founder of the Indian Academy of Scientists, delivered a series of radio addresses to the Indian public. They were so well received that they have been collected and edited and arranged to form this interesting and useful little volume.

Addressing primarily the non-scientist, Dr. Raman discusses the physics of certain parts of nature with which all come in contact, such as soil, weather, crystals, water, light, color, the stars, etc. He ventures a few predictions under the chapter headings "The Future of Physics" and "The Scientific Outlook." A worth while addition to the school library.

H. C. M.

Tracerlab

(Continued from Page 113)

It is the function of Tracerlab to design and supply for the potential users of radioactive isotopes the equipment, facilities, safety devices and consulting services which are requisite for satisfactory radioactivity applications. The Company maintains a direct mail Film Badge Service for the protection of personnel against excessive radiation. More than 2200 Film Badges per week are processed.

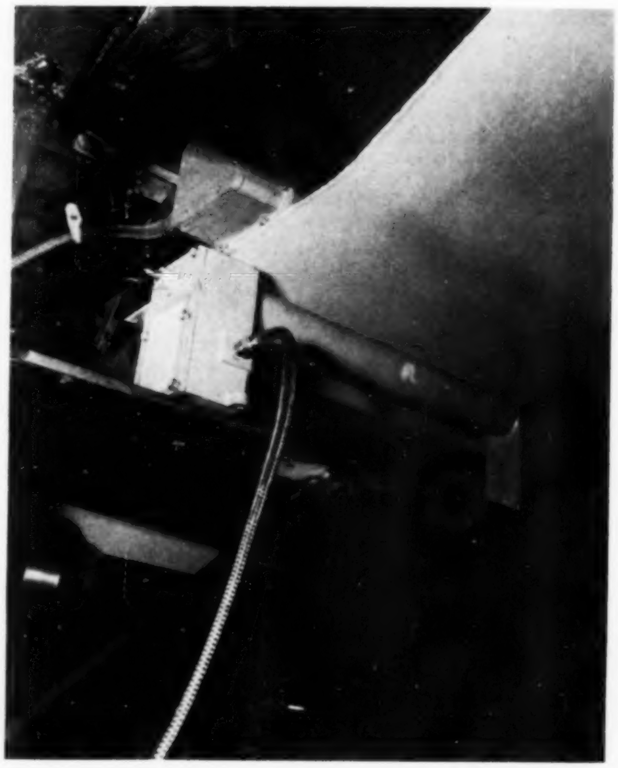
The design and construction of nuclear instruments have been a specialty of Tracerlab since its inception in 1946. A complete and unrivaled line of equipment is being produced in Tracerlab's own plants, which are geared for all production requirements. Many of these nuclear instruments require the use of Geiger-Mueller tubes. Tracerlab manufactures a number of different types of detecting tubes and thus can provide the necessary equipment for all types of radioactivity applications.

Tracerlab's growth in the industrial applications field is making good progress. Instruments have been developed to control automatically many continuous industrial processes through the use of radioactivity. The Beta Gauges, which include both absorption and backscattering types, measure non-destructively the weight per unit area or thickness of sheet material that is being processed without contacting or interfering with the flow of the material. Backscattering type gauges are used for measuring the thickness of coatings—such as the coating applied to paper—and can also be used to measure the weight per unit area or thickness of sheet material passing over a calendar roll or other backing material. A number of these instruments have been installed and are now in use gauging such materials as floor covering, rubber, paper, copper, brass, thin steel sheets, aluminum, adhesive tape, and other sheet materials.

Another important industrial product is cobalt-60 in the form of sealed radiography sources, used for the non-destructive inspection of materials for flaws which might cause failure in use.

Since its inception, Tracerlab has performed a great deal of vital work for various government agencies as well as the Atomic Energy Commission in the fields of research, development, consultation, and production, and is currently working on approximately twenty-one government contracts ranging from unclassified to top secret.

Another important branch of Tracerlab's business—developed within the last year or two—is the design and manufacture of Civil Defense instruments, and the supplying of these instruments to various branches of the armed forces as well as to local and state CD units. Tracerlab now has in mass production the only instrument approved by the F.C.D.A. for medium level monitoring.



TRACERLAB BETA GAUGE in use in a paper mill measuring the weight per unit area (or thickness) of paper for closer control and raw material saving.

Another important program which reached fruition during 1950 was that of manufacturing crystals for scintillation counting. Various organic crystals, such as stilbene, are being grown, machined, and marketed by the company.

Since its founding, company sales have grown from approximately $30,000 in 1946 to $1,700,000 in 1950 and it is anticipated that company sales will be between $3,000,000 and $4,000,000 in 1951. In this same period the number of employees has expanded from 14 to approximately 500, while the floor space occupied has gone from 4,500 square feet to approximately 83,000 square feet. ●

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Sleeping With Science

(Continued from Page 110)

sistance to light and heat ageing, and soap, together with other surface active agents, for frothing and compound stabilization. It may be mentioned that many of the secrets of the foam manufacturer are connected with the process of compounding. After the latex compound is prepared, it is matured for a definite time at a definite temperature, a process which irons out the differences in behavior to be expected from the different shipments of latex.

The next step on the road toward sleeping comfort is frothing, during which the proper amount of air is mixed with the latex compound. Frothing or beating is continued until a given density is obtained which determines the softness of the finished product. On a small scale, the latex compound might be frothed in an ordinary electric kitchen mixer; the principle is the same as in the beating of egg whites for angel food cake. But on a production scale, larger and more practical vessels holding batches of one hundred pounds or more are used for this king-sized beating operation.

As soon as the batch of froth is light enough, the worker on the job adds to it a slurry of zinc oxide, followed by one of sodium silicofluoride to sensitize the froth in order that gelation, an oriented coagulation, may occur after exactly the right time has elapsed. Before this gelation occurs, the froth is poured into a mattress mold and covered with a suitable top plate. After a few minutes the frothed latex, now in the mold, reaches a dough-like consistency. With gelation completed, the mattress material and mold are transferred for curing to the vulcanizer. A vulcanizer is a suitably sized chamber in which an atmosphere of live steam is maintained.

During the curing cycle the sulfur in the latex combines chemically with the rubber hydrocarbon and transforms the gel from a dough-like mass into an elastic and resilient piece of foam. After this metamorphosis, the mold is taken out of the vulcanizer and its hot, wet contents removed.

Washing, which removes all water-dispersible and odor-bearing substances, comes next. It is accomplished in machines which are designed alternately to compress and release the foam in a stream of fresh water. After careful washing the mattress is squeezed through wringer rolls to remove excess water.

From the washer the mattress moves into the drier, where air heated to a temperature of approximately 200°F. circulates through it to remove the remaining moisture. Thorough drying may require eight to twelve hours depending on the thickness of the foam.

Process Control

Highly technical, the latex foam process requires the attention of expert chemists and engineers in every stage of the product design and process control. Some of the technicians work in analytical and physical testing laboratories, while others follow each stage of manufacturing to ensure compliance with the technical specifications which have been established to govern the uniformity of the product. Wherever possible, statistical methods employing chart control are used in the collection and analysis of operating data.

Product Design

So far, we have watched the progress of a foam latex mattress from rubber plantation to you, a process in which many hands and minds have worked to provide us comfortable sleeping. Now let us go back to the time when this soft-sleeping foam is only a gleam in the designer's eye.

A mattress is made to sell, and the first consideration of the manufacturer, even before comfort, is the good appearance of his product on the sales floor, and more important of course, in the home where it is actually used. The designer plans a good-looking mattress with a crown, so that when it is made up in the store or in the bedroom its appearance pleases the eye. For handsome protection the mattress is usually covered with a soft-textured fabric of high quality, made a little smaller than the foam itself, which pushes out against the cover, keeping it relatively free of wrinkles.

The actual comfort engineering feature appears below the surface. Taking off the cover of one of these mattresses, you would find, if you took the trouble to count them, over 5,000 small comfort holes, or core holes as they are called in the trade, which are molded into the foam latex to enable it to adjust to your individual contours. Whether you are a flyweight or a heavyweight, you can be sure that this mattress will fit you, and give you a restful sleep. These 5,000 core holes fill another need. Contrary to a popular belief, it is just as cool to sleep on a foam latex mattress when the thermometer is hovering at 90° as it is on any ordinary cotton padded one. The difference between the two, according to all tests conducted so far in the industry, is so small that it falls within the range of experimental error. The core holes also help the mattress to breathe. They allow air to circulate freely and thus carry away body perspiration.

Mattress Production

At the present time hundreds of thousands of happy sleepers are using foam latex mattresses and the current rate of manufacture is estimated at almost 250,000 every year. It has expanded from a small volume before World War II to its present volume in the six years since the end of the war.

Most of this discussion concerns sleeping with science, but users of foam latex not only sleep, but ride and sit with science as well. Science and engineering working together are producing foam latex products for use everywhere. In automobiles we sit on cushions and rest our backs against foam pads which are usually placed directly under the upholstering material. In trains, thousands of foam units make reclining chair

cars more comfortable. Foam mattresses are found in Pullman sleepers. In civilian and military aircraft, foam cushions and backs have found a limited use. Patients in hospitals use foam mattresses, pillows, and invalid rings. In the furniture industry foam cushions have gained in popularity tremendously within the past two years. Producers of cross-country and city busses use foam cushions in increasing amounts each year. In fact, any place where the human anatomy needs support while kneeling, sitting, or reclining, foam latex cushioning finds an increasing use. ●

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Truth About Lie Detector

(Continued from Page 124)

they call you Red?", and, "Do you live in Chicago?" The third and pertinent question, (e.g., "Do you know who shot John Jones?") is followed by another irrelevant question. By asking an irrelevant question at No. 4, a norm can be re-established prior to asking the most important question on the test: "Did you kill John Jones?"

A "guilt complex" question is asked at No. 6, which is based upon an entirely fictitious crime of the same type as the actual crime under investigation but one which is made to appear very realistic to the subject. For instance, if the subject is being examined regarding the actual murder of John Jones he may also be asked about the murder of Jim Kearns, an entirely fictitious person and an entirely fictitious crime. The purpose of the "guilt complex" or fictitious crime question is to determine if the subject, although innocent, is unduly apprehensive because of the fact that he is suspected and interrogated about the crime under investigation. A reaction to the fictitious crime question which is greater than or about the same as that to the actual crime question would be indicative of truthtelling and innocence respecting the real offense. On the other hand, however, a response to the actual crime questions, coupled with the absence of a response to the fictitious crime question, or by one considerably less than that to the actual crime questions, would be strongly indicative of lying regarding the offense under investigation. In other words, the reaction to the one question based upon the actual crime must be accounted for by guilty knowledge or responsibility rather than by nervousness or other factors, for otherwise the fictitious crime question should provoke a similar type of reaction.

Question No. 7 is again irrelevant, and questions No. 8 and No. 9 pertain to the crime under investigation. Repeated tests coupled with consistent responses (e.g., rises in blood pressure and suppressions or irregularity in the respiration as well as greater quantities of perspiration) on questions pertaining to the crime under investigation lead the examiner to report the subject's guilt, while consistent regularity in the sub-

ject's blood pressure-pulse and respiration is indicative of truth telling.

Lie-detector records are not admissible as court evidence at the present time even though the technique, in the hands of a competent, trained examiner, has attained a high degree of accuracy. We may be sure, however, that with continuing development and new techniques the lie-detector will be admitted as evidence within the next decade. ●

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Electrons on Bacteria

(Continued from Page 121)

taken from another slide wire resistor connected be tween the target and the second plate.

The bacteria, staphylococcus aureus, are taken from a stock culture grown on nutrient agar. A 1:100 dilute suspension is made. A drop of the suspension is spread on the target and allowed to dry. The target is then assembled in the tube and the evacuation begun. After the tube has been evacuated, the voltages are adjusted to give the desired amount of total emission current. When the specified time allotted for bombardment has elapsed, the bacteria are removed by pressing the target gently against a sterile petri dish containing nutrient agar, using as far as possible sterile technique. After at least twenty-four hours of incubation at 37°C., the bacteria are examined for texture, color, and other superficial characteristics. These changes are noted by means of a microscope. Colonies showing any of these changes are plated out on nutrient agar. If the change is to be accepted as genetic, it must become an inherited property. With every experimental, a control is run. To determine the lethal mutations, plate counts are made. The plates used to determine the number killed are also used as material for calculating the rate of growth and biochemical effects.

To compare the rate of growth of the control against that of the experimental, suspensions were made. In order to obtain inocula of equal size and viability, a loop of each culture is inoculated in 10 cc. of nutrient broth and incubated for seventy-two hours. The relative growth rate of each culture was determined by means of an electrophotometer. Results showed that

the mutant strains consistently grew at a greater rate than did the parent strain.

For biochemical tests, crystal violet lactose agar, bromthymol blue lactose agar, and phenol red mannitol agar were used. If the growth on crystal violet lactose agar was purple or deep yellow, it was interpreted as coming from a hemolytic and coagulating strain. Bromthymol blue lactose agar acts as an inhibitor of nonpathogenic staphylococcus. Phenol red mannitol agar is used as a control for the other two media. Results showed that as the time of bombardment was increased, the growth became heavier and deeper in color.

In conclusion, it may be said that although mutations do occur spontaneously, radiation by means of slow electrons plays a definite role in increasing and hastening the frequency of mutations in bacteria. ●

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What About Dry Ice?

(Continued from Page 112)

liquid to the freezing point to finish the process. A third method involves evaporating part of the liquid carbon dioxide in several stages and ultimately solidifying the rest of it by the cooling effect of its own evaporation.

The final result, whichever method is employed, is the production, by compression, of a solid, glassy cube, 10 inches on each edge and weighing approximately 50 pounds. Frequently the press in which the blocks are formed makes pieces 10" x 20" x 20" which are sawed into four cubes on a band saw. The blocks are individually wrapped in paper bags to keep air away from them, and are stored or shipped in heavily insulated containers.

Dry ice, by reason of its low temperature, is the ideal refrigerant for the storage and shipment of ice cream. The meat packer is particularly interested in solid carbon dioxide refrigeration because the off-coming gas effects a definite improvement in the final condition of his product. Eggs in cold storage are maintained in a fresh condition for a much longer period if the atmosphere of the storage space is supplied with regulated

amounts of carbon dioxide. The gas also benefits cut flowers.

Despite its advantages, the use of dry ice as a refrigerant seems likely to be limited by its cost. In mobile refrigeration of trucks and freight cars, the weight reduction which it makes possible yields a return great enough to offset its high cost. And, where extremely low temperatures are needed, it has a cost advantage over most refrigeration systems. ●

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Effects of Radiation

(Continued from Page 123)

be trying to live in the United States. This increase in itself is serious, considering present exploitation of non-renewable natural resources, but considered in the light of the aforementioned problems it may be disastrous. Each member of our species needs to realize fully the problems that confront us, for they are largely man-made, and we have at present the intelligence to solve them if we choose to use it.

These then are the problems, problems that, at least to a degree, can be recognized and solved purely on biological grounds. In the case of the sex-linked genes, it is possible to cut down the frequency of these abnormalities to about one-half by discouraging the breeding of homozygous males and heterozygous women. Longer institutionalization would result in segregation of unfit individuals, thereby lowering their chances of propagation. Such a direct attack, however, would not reduce the frequency of these hereditary abnormalities to any great extent since all heterozygous individuals could not be recognized and therefore would not be subject to segregation. The only approach whereby both homozygous as well as heterozygous individuals with hereditary abnormalities may be prevented from propagating under such conditions is through the medium of an intensive educational program, a program designed to equip each individual with the knowledge that will enable him on an individual basis to plan and execute a program of selective breeding. We cannot improve the human species by compulsion. We may, however, be able to moralize more realistically our reproductive behavior through education.

The future of atomic research and the use of atomic energy will determine in a large measure what our species can expect for the future. A thorough understanding, or at least a working knowledge, of the principles of heredity can do much toward our formulation of a solution of current and future problems concerning human heredity. While there is still time, ***Homo sapiens*** might well take stock of the situation, and utilize his superior intelligence, if not to stem the tide, to prepare for changes, physical, mental, social, economic, and otherwise in his species. ●

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Chemical Investigation

(Continued from Page 115)

objects for study or for exhibition in museums. Since the deterioration of buried objects is predominantly the result of chemical change, it is therefore reasonable to expect that the restoration of such objects should be best effected by chemical treatment, and the nature of such treatment may be indicated by the composition of the objects. The deterioration of bronze, for example, is primarily the result of oxidation, and the reverse process of reduction should tend to restore the bronze to its original condition. This principle has been applied with much success to the restoration of bronzes by means of electrolysis. In ordinary air the corrosion of an ancient metal object may continue at an appreciable rate unless proper precautions are taken. Such an object may be best preserved in a glass case containing a powerful drying agent or even in a sealed case containing an inert gas. Many other problems of restoration and preservation have been successfully solved by the application of chemical principles.

Much remains to be done before our knowledge of the chemical composition of ancient materials and objects reaches a satisfactory state. Indeed, much of the information obtained up to the present time is fragmentary and unsystematic, and practically nothing is known about certain kinds of materials and objects. Similarly, much remains to be done before our knowledge of the composition of ancient materials and objects can be properly applied to the solution of many interesting problems in archaeology and history. ●

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Genetics and Evolution

(Continued from Page 120)

not usually produce offspring sexually, and no one would agree with that conclusion. Recent results indicate that there are sex strains even in bacteria though the process has not been seen under the microscope. It is possible that sexual reproduction will eventually be found in forms now thought to have asexual reproduction only. Different races of *Diptera*, when crossed, will produce various percentages of viability, and where shall we draw the line? A stock of *D. melanogaster* can be produced which would breed true, but which would kill off seven-eights of all the offspring in each generation due to balanced lethals. Yet no geneticist would consider this a new species, not even a new race.

Hereditary changes are constantly taking place, more frequently in some forms, less frequently in others, and the inability of the taxonomists to come to a definite conclusion in regard to species is an indication that evolution is still occurring before our very eyes, but the process is exceedingly slow. The solution of the problem is in the hands of the geneticist. ●

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"The success of science involves a number of observations and concepts of a great many people; it is achieved by cooperative human effort. It is a story of the skills and talents of men. Cataracts and detours are far apart. Developments and achievements build upon ideas and concepts dating back through many years. There is no black magic along the path of science, no talisman secretly possessed by scientists which vouchsafes success. The scientist has no inner light, no esoteric intuition. Sir Humphrey Davy, one of the greatest of scientists who lived one hundred and twenty-five years ago, said: "Practically all of the contributions it has been my good fortune to make were suggested to me by failures."

—*Ideas, Men and Things*

J. O. PERRINE

Some Types of Antifreeze Can Cause Damage to Your Car

With cool weather just around the corner don't wait until the first freeze to have your car looked after, and be careful what antifreeze you buy, warns the National Bureau of Standards. Some antifreezes can do more harm than good to the family car.

To safeguard motorists the National Bureau of Standards has published a booklet, "Automotive Antifreezes," which goes into detail about winter radiator solutions, both good and bad. The cleaning and the preparation of a cooling system is also discussed. This should be done early so that antifreeze may be put in about the time of the first frost, the NBS advises.

Antifreezes considered safe for ordinary use by the NBS are ethylene and propylene glycol as well as the simple alcohols—such as wood alcohol. But NBS research indicates that antifreezes made with a salt-base or from petroleum distillates similar to kerosene are definitely harmful.

Strong corrosive action was noted in the tests with the salt-base solutions such as calcium, magnesium, and sodium chlorides. The NBS experiments showed that corrosion was not stopped by inhibitors (chemicals added to retard corrosion). The NBS report reveals that all the metals of a cooling system are attacked by the salt-base antifreezes. The corrosion is most pronounced on aluminum, which is completely eaten away in many of the tests

The booklet warns that continued use of salt-base antifreezes not only leads to extensive corrosion and clogging of the radiator, but may eventually cause the motor block to crack.

The petroleum-base antifreezes were found harmful for three entirely different reasons; they are highly inflammable; they rapidly cause rubber hose connections to deteriorate; and their boiling points are far too high.

Actual tests made on government vehicles showed ordinary rubber hose connections cracked and broke after less than 65 days use. The boiling points of petroleum-base antifreezes were found to be above 400 degrees. It is conceivable, the scientific report claims, that a car could be driven until the engine becomes so hot that failures result before the driver is aware of the overheating.

Of all the solutions tested only the simple alcohols listed as methyl, ethyl, and isopropyl alcohol and ethylene and propylene glycol were found to be safe antifreeze materials. Their boiling points when mixed with water are not significantly different from that of water itself; they are not easily ignited; and when proper inhibitors are added they have little corrosive or deteriorating action.

There are several methods by which the various antifreezes can be identified. The easiest is by igniting rags soaked in their solutions. The alcohols burn with a clean, blue flame; petroleum-base solutions cause a smoky yellow flame; and salt-base antifreezes do not burn.

"Automotive Antifreezes" describes further qualitative tests for identifying antifreezes which can be performed by the average car owner. The booklet also contains tips on cooling systems for car owners. It can be obtained by sending 15 cents to the Superintendent of Documents, Government Printing Office, Washington 25, D. C., requesting NBS Circular 474, "Automotive Antifreezes." ●

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New Values of Electrical and Photometric Units Established

By an act approved July 21, 1950 (Public Law 617), the 81st Congress gave formal statutory sanction to a revision of the practical system of electrical units. In large part, the values adopted for these units resulted from research by the National Bureau of Standards, and the present legislation was proposed by the Bureau. The changes in magnitude of the units are small, in no case larger than 1/20 of one per cent, but the new law puts the values on a clear and unambiguous basis which assures the closest practicable agreement between electrical and mechanical units.

The law previously in effect, enacted 56 years ago, included double definitions of the units. There were no central standards laboratories at that time, and to enable any competent laboratory to set up valid electrical standards the United States law, as well as international agreements, prescribed certain devices to produce three basic units. The ampere was defined by the rate of deposition of silver in a voltameter or coulometer, the ohm as the resistance of a specified column of mercury, and the volt as a specified fraction of the electromotive force of a certain type of standard cell.

It was later found that these conventional standards did not produce exactly the intended values of the units. Technical and scientific developments, including the use of electrical instruments for many kinds of measurement, made it increasingly inconvenient to have electrical units not strictly consistent with those of mechanics. Furthermore national standards laboratories were established in all of the larger industrial countries. These laboratories maintain the basic standards of measurement so that the need for the old system of reproducible electrical standards has disappeared.

Recognizing these changed conditions, the American Institute of Electrical Engineers in 1928 proposed a return to the basic "absolute" units. Twenty years

of research and negotiation were required to bring about unanimous international action to this end, in which the National Bureau of Standards played a leading role. The story of this accomplishment is told in detail in NBS Circular 475, "Establishment and Maintenance of the Electrical Units" (Superintendent of Documents, Government Printing Office, Washington 25, D. C., 25 cents per copy).

The new Act is similar to the old law in defining the fundamental practical units as multiples of the units of the centimeter-gram-second electromagnetic system. In fact, however, they are also component parts of the meter-kilogram-second system which is being widely accepted in textbooks and in engineering practice. Two sections of the Act define the basic photometric units, the candle and the lumen, which were not previously defined by law.

The provisions of the law are as follows:

That from and after the date this Act is approved, the legal units of electrical and photometric measurement in the United States of America shall be those defined and established as provided in the following sections:

Sec. 2. The unit of electrical resistance shall be the ohm, which is equal to one thousand million units of resistance of the centimeter-gram-second system of electromagnetic units.

Sec. 3. The unit of electric current shall be the ampere, which is one-tenth of the unit of current of the centimeter-gram-second system of electromagnetic units.

Sec. 4. The unit of electromotive force and of electric potential shall be the volt, which is the electromotive force that, steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere.

Sec. 5. The unit of electric quantity shall be the coulomb, which is the quantity of electricity transferred by a current of one ampere in one second.

Sec. 6. The unit of electrical capacitance shall be the farad, which is the capacitance of a capacitor that is charged to a potential of one volt by one coulomb of electricity.

Sec. 7. The unit of electrical inductance shall be the henry, which is the inductance in a circuit such that an electromotive force of one volt is induced in the circuit by variation of an inducing current at the rate of one ampere per second.

Sec. 8. The unit of power shall be the watt, which is equal to ten million units of power in the centimeter-gram-second system, and which is the power required to cause an unvarying current of one ampere to flow between points differing in potential by one volt.

Sec. 9. The units of energy shall be (a) the joule, which is equivalent to the energy supplied by a power of one watt operating for one second, and (b) the kilowatt-hour, which is equivalent to the energy supplied by a power of one thousand watts operating for one hour.

Sec. 10. The unit of intensity of light shall be the candle, which is one-sixtieth of the intensity of one square centimeter of a perfect radiator, known as a "black body," when operated at the temperature of freezing platinum.

Sec. 11. The unit of flux of light shall be the lumen, which is the flux in a unit of solid angle from a source of which the intensity is one candle.

Sec. 12. It shall be the duty of the Secretary of Commerce to establish the values of the primary electric and photometric units in absolute measure, and the legal values for these units shall be those represented by, or derived from, national reference standards maintained by the Department of Commerce.

Sec. 13. The Act of July 12, 1894 (Public Law Numbered 105, Fifty-third Congress), entitled "An Act to define and establish the units of electrical measure," is hereby repealed. ●

Radioactive Tracers Used to Study Plating Process

A better understanding of the mechanism of electrodeposition in chromium plating has resulted from recent studies by Fielding Ogburn and Abner Brenner of the National Bureau of Standards using radioactive tracer techniques. By tagging either the trivalent or the hexavalent chromium in a chromic acid plating bath with radioactive chromium 51, it was conclusively shown that metallic chromium is deposited out of the bath from the hexavalent state rather than from the trivalent state, as had previously been suggested. In addition to solving a long-standing problem in electrochemistry, the work has demonstrated the utility of tracer methods as a tool for research on industrial plating processes.

Chromium plating is widely used to provide a hard wear-resistant coating on machine parts and for decorative purposes on such products as automotive grillwork and bathroom fixtures. For commercial plating of this kind, the chromic acid bath, first reported in 1856, is at present practically the only chromium plating solution in use. This bath is prepared by dissolving chromic acid anhydride (CrO_3) and a little sulfuric acid in water. Initially, all of the chromium in the solution is in the hexavalent state; but when the plating current is applied, an excess of some trivalent chromium is formed by reduction of the hexavalent chromium at the cathode. This has led to numerous investigations into the mechanism of the electrodeposition process to determine whether the chromium is deposited directly from the hexavalent state or through the trivalent form. The National Bureau of Standards therefore undertook to determine experimentally the source of the electrodeposited chromium by use of radioactive tracers.

Five chromic acid plating baths were prepared, and a small quantity of radioactive trivalent chromium was added to two of the baths as chromic chloride ($CrCl_3$) while hexavalent chromium was added to the other three baths as radioactive chromic acid anhydride (CrO_3). Chromium deposited from the first two baths was inactive. On the other hand, deposits from the baths in which the hexavalent chromium was tagged were found to be radioactive, and their activities were close to those of deposits from a bath containing active hexavalent chromium and no trivalent chromium. It was thus evident that the metal is deposited from the hexavalent rather than the trivalent state.

Chromium 51 is a soft gamma ray emitter with a half-life of about 26 days. Its radioactivity in the solutions and the deposits was measured by means of a thin-walled gamma ray counter connected to a scaler. At the end of the plating process the Geiger counter was placed within the brass-cylinder cathode and the activity of the deposit was counted for 30 minutes. The tube was then rotated through 180°, and counting was continued for another 30 minutes. A background count was also made with an unplated brass tube for the same period of one hour and was subtracted from the count for the plated tube. ●

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